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Roots of Tomorrow's Digital Divide: Documenting Computer Use and Internet Access in China's Elementary Schools Today

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Abstract

This paper explores China's digital divide, with a focus on differences in access to computers, learning software, and the Internet at school and at home among different groups of elementary school children in China. The digital divide is examined in four different dimensions: (i) between students in urban public schools and students in rural public schools; (ii) between students in rural public schools and students in private migrant schools; (iii) between migrant students in urban public schools and migrant students in private migrant schools; and (iv) between students in Han-dominated rural areas and students in areas inhabited by ethnic minorities. Using data from a set of large-scale surveys in schools in different parts of the country, we find a wide gap between computer and Internet access of students in rural areas and those in urban public schools. The gap widens further when comparing urban students to students from minority areas. The divide is also large between urban and rural schools when examining the quality of computer instruction and access to learning software. Migration does not appear to eliminate the digital divide, unless migrant families are able to enroll their children in urban public schools. The digital divide in elementary schools may have implications for future employment, education and income inequality in China.

Key words: China ethnic minorities, digital divide, rural China, urban China
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I. Introduction

Over the past two decades, information and communication technology (ICT) has increased connectivity and access to information resources all over the world. The opportunities that this technology provides have prompted the development and proliferation of hardware, software and affordable Internet connections (Bresnahan and Traitenberg, 1995). Through increasing the productivity of individuals, ICT has become an important contributor to economic growth (World Bank, 2006; OECD, 2009).

However, if ICT is only available to some groups of individuals in a society but not others (henceforth, a phenomenon that we call the digital divide), the resulting disparity in access to ICT is likely to lead to income inequality and poverty for those individuals without access. Differences in access to health and educational services can lead to overall inequality in a country (Attewell and Battle, 1999), and the same is true for differences in access to employment (International Telecommunication Union, 2006). At the aggregate level, it has been shown that there is a negative relationship between inequality and growth (Benabou, 1996). It can be argued that the seriousness of the digital divide in a country has important implications for its growth path.

Scholars have examined the nature of the digital divide in both developed and developing countries around the world. In the USA, 80 percent of those earning over US$75 000 have access to the Internet at home, whereas only 25 percent of the USA's poorest households can access the Internet at home (Dickard and Schneider, 2002). Similarly, according to a Canadian Internet Use Survey, a digital divide exists between higher and lower income households in Canada (Statistics Canada, 2008). The survey points out that 91 percent of people who earn more than US$91 000 per year regularly access the Internet, compared to 47 percent of those with annual incomes of less than US$24 000. In India in 2008, the rate of access to the Internet of urban households was 10 times that of rural households (Singh, 2010).

In the past decade, government officials and researchers have become interested in documenting and measuring the digital divide in China. A mid-2000s study reported that access to the Internet was more than three times as common in urban areas (27.4 percent of urban households) than in rural areas (7.2 percent) (China National Bureau of Statistics, 2007). The same study found similarly large discrepancies in ICT access between rich and poor households.

Judging the accuracy of these official statistics can be difficult. Reports rarely provide details on the coverage of surveys, sampling frames are almost never specified and sources

of information are frequently absent.[1] Information on ICT is also generally not analyzed. For example, the correlates of access to ICT are rarely, if ever, discussed, and many of the statistics in the papers are reported in aggregate form only. In fact, in one of the most carefully documented papers in the published literature the entire sample contains only five villages (Wang, 2001).

Given this absence of high quality, verifiable and detailed information on China's digital divide, the overall goal of the present paper is to provide an overview of gaps in access to ICT in China. To meet this goal, we have two specific objectives. First, we document the digital divide, focusing on disparities in computer ownership, computer use and Internet access. Second, we examine the depth of computer usage, as represented by knowledge of higher-order computing skills. We compare the digital divide that separates four different groups: (i) students in urban public schools and students in rural public schools (the urban–rural digital divide); (ii) students in rural public schools and students in private migrant schools (the rural–migrant digital divide); (iii) migrant students in urban public schools and migrant students in private migrant schools (the urban–migrant digital divide); and (iv) students in Han-dominated rural areas and students in rural areas that are inhabited by ethnic minorities (the Han–ethnic minority digital divide).

There are limitations to our proposed analysis. First, our empirical evidence on the digital divide is limited to elementary school students. Although this, admittedly, is only one segment of China's population, access to ICT during childhood is a strong predictor of expertise in ICT in adulthood (Baouendi and Wilson, 1989). By focusing on student familiarity, we are studying the future of China's digital divide. Second, while our samples from China's urban and rural public schools and migrant private schools are relatively large and randomly sampled across selected parts of China, we cannot claim external validity to all of China. Although we must be careful in claiming external validity of our results, we know of no reason why our findings are not representative of broader trends.

The present paper is organized as follows. In the following section we describe our survey data. Our results section examines the nature and magnitude of four identified digital divides: urban–rural; rural–migrant; urban–migrant; and Han–minority. The final section concludes.

II. Data

A reliable analysis of the digital divide requires high quality data. Despite the efforts

[1] For example, a report by the Chinese Information Center neglects to provide details on the coverage of its survey; Xia (2010) does not specify a sampling frame; and Wang (2001) does not report the source of his information.

devoted to this issue by scholars (e.g. Wang, 2001), there is still an absence of school-based ICT data that is disaggregated by region and social group. This paper responds to the need for region-specific data on urban, rural, migrant and ethnic minority-populated areas.

In 2009 and 2010, our research group conducted surveys of students in four types of elementary schools: urban public schools (these included both students with urban household registration or *hukou*, henceforth *urban students*; and students whose parents are migrants, but who attend urban public schools, henceforth, *migrant students in urban public schools*); rural public schools (*rural students*); migrant private schools (*migrant students in private migrant schools*); and rural public school students in ethnic minority areas (*ethnic minority students*). The data used in the present study were collected during four separate enumeration efforts. We will describe the datasets, which are summarized in Table 1, in the rest of this section.

1. Urban Public School Data (Urban Students and Migrant Students in Public Schools)

The Urban Public School Survey collected data on two types of students. In the 9 schools in the sample, approximately 10 percent were urban students who had Beijing household registration, meaning that at least one of their parents was a Beijing resident.[2] The other

Table 1. Summary of Datasets Used in Digital Divide in China Study

School type	Student type(s)	Location of sample schools	Number of sample schools	Number of sample students
Urban public schools[a]	Urban students and migrant students in urban public schools	Beijing (suburbs)	9	1458 fourth-grade students (154 urban students; 1304 migrant students in urban public schools)
Rural public schools[b]	Rural students	Shaanxi Province, Ankang Prefecture	72	2666 third and fifth-grade rural students
Private migrant schools[c]	Migrant students in private migrant schools	Beijing (suburbs)	43	4103 third-grade migrant students in private migrant schools
Rural minority public schools[d]	Rural minority students	Qinghai Province, Haidong Prefecture	26	2587 third and fourth-grade rural minority students
Total			150	In total we surveyed and report on the access to information and communication technology of 10 814 students

Notes: [a]For more information, see Sharbono (2010). [b]For more information, see Shi *et al.* (2012). [c]For more information, see Lai *et al.* (2011b). [d]For more information, see Luo *et al.* (2011).

[2] China's *hukou* household registration system classifies China's citizens as either rural or urban residents. Without an urban *hukou* migrants and their families have limited access to urban public services, including housing, health care, social security, and education. Since the mid-2000s, if there is room in urban public elementary schools, migrant students have been allowed to matriculate and have been treated as urban students in terms of tuition, fees and most other services while in school. See Naughton (2007).

90 percent were migrant students in urban public schools.

The Urban Public School Survey consists of 9 randomly selected public schools in the outskirts of Changping, Haidian and Chaoyang Districts in Beijing. We intentionally chose schools on the outskirts of Beijing so they would contain a mix of urban students and migrant students in urban public schools.

Although the schools were chosen randomly, they are not representative of Beijing schools in general. According to interviews with officials in the Chaoyang and Haidian bureaus of education, the public schools represented in the Urban Public School Survey can best be classified as lower–middle tier in terms of quality when compared to other public schools in Beijing. These schools enroll more low income students than the typical public school in Beijing, and exhibit comparatively low rates of academic achievement. We bear this in mind when interpreting the results, as we are considering the situation of relatively poor urban students. It is likely that the digital divide would be wider if we were to sample from urban students attending Beijing's highest quality schools.

Despite their below-average status, the schools in this dataset are still located in one of China's richest province-level administrative regions. These schools all receive public funds and, thus, cannot be considered under-resourced. A previous report comparing the schools in this dataset to a sample of randomly-selected private migrant schools found that the facilities, teachers and curriculum for these urban schools were of much higher quality than those at the private migrant schools (Lai *et al*., 2011a). Because urban public schools are free and of higher quality, migrant parents generally send their children to private migrant schools only when there is no room in local urban public schools. Although there is no formal sorting rule by which migrant children can access urban schools, it appears that there is a systematic difference in the type of migrant family that is successful in getting their child into public school. This difference indicates that school quality is not the only factor in the disparity between these two groups. According to Lai *et al.* (2011b), migrant students in urban schools score significantly higher on standardized exams than migrant students in private migrant schools. The parents of migrant students in urban schools have higher levels of education and have generally resided in Beijing for longer periods of time than parents of migrant students in private migrant schools. We must consider these systematic differences in family characteristics when comparing the digital divide between migrant students at private schools and those at urban public schools.

The second step in the data collection process was to survey students in the schools. Our survey focused on the 1458 fourth-grade students in the 9 urban schools in our sample. Among all fourth-grade students in the urban schools, 154 were urban students (with Beijing household registration) and 1304 were migrant students in public schools. The students involved in our survey were given a questionnaire that included the following

items: whether students use computers at school; how many times students use computers at school every week; the quality of the computer classes, including the type of computer skills taught and the frequency they meet; whether students use computers at home for study; whether the student's family owns a computer; and whether the student has access to the Internet at home. All of these questions were related to computer access and use, the quality of computer education and access to the Internet.

2. Rural Public School Data (Rural Students)

The data on rural public schools come from Shaanxi Province. In Shaanxi, approximately 60 percent of the population lives in rural areas (National Bureau of Statistics, 2011). In 2005, the incidence of rural poverty in Shaanxi was 2.9 times higher than the national average (OECD, 2009). Since 1981, Shaanxi has also had one of the slowest rates of poverty reduction in rural China (Martin and Chen, 2007). Because of these distinguishing characteristics, we must note that the urban–rural digital divide will be overstated compared to a completely random sample of rural students. We can assume that access to ICT technologies is better in wealthier rural areas.

The site of the rural public school survey was chosen to be in Ankang Prefecture. The prefecture is located immediately south of Xi'an, the capital of Shaanxi Province. All of the counties are located in the Qingling mountain range. Ankang Prefecture is home to one of the poorest groups of counties in China. Of the seven counties in Ankang, four are nationally-designated poor counties.[3] We chose to carry out the study in these four counties.

The process of selecting our sample was as follows. First, we obtained a list of all schools in each county. We then narrowed this list to include only elementary schools that contained six full grade levels (*wanxiao*). From the full list of *wanxiao* in the four sample counties, we randomly selected 72 schools. These 72 schools contained a total of 2666 third-grade and fifth-grade students.

The rural public school ICT survey was launched in February 2011. All 2666 third and fifth-grade students were included in the survey. The questionnaire was nearly identical to the urban public school survey. All the questions on access to computers and the Internet were the same; however, due to time limitations when conducting the survey, there were fewer questions on how computers were used in class.

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[3] In 1994, the Chinese Government launched a poverty-reduction initiative under the "8–7 Plan," with the major objective of raising per-capita income to 500 yuan (in 1990 prices) within 7 years. This plan targeted 592 designated poverty counties in the country. Poverty reduction, especially in China's west, remains a formidable challenge today. When we say "poor county" in this paper, we mean that the county is designated by China's government as being a poor county in the poverty reduction program.

3. Private Migrant School Data (Migrant Students in Private Migrant Schools)

The sample of private migrant schools in Beijing was chosen from a sampling frame covering almost all private migrant schools in the city. Unlike public schools, no official list of Beijing migrant schools is available. To collect a comprehensive list of migrant schools in Beijing, we contacted all educational and research institutes and non-profit organizations in the greater Beijing area that might have contact information for Beijing migrant schools. We then called each school to confirm that it was still open, and asked the principal if there were any other schools in their area. Using this approach, we established what we believe to be as complete a database of Beijing migrant schools as possible. A total of 230 elementary schools were on our list.

We selected our sample schools from this comprehensive list. For ease of implementation, we restricted our sample to three districts in Beijing among those most densely populated by migrants and migrant schools. Of the 230 schools in the database, 69 schools were in these three districts. We then proceeded to exclude schools that had only one class in the third grade (i.e. there was only one grade 3 class instead of two or more grade 3 classes in the school). We applied this strategy in a separate study (Lai *et al.*, 2011b). Hence, our sample of private migrant schools is representative of all large private migrant schools in Beijing. In total, 43 schools met the criteria of having two or more grade 3 classes. A total of 4103 students in 98 classes of 43 Beijing migrant schools were surveyed.

Consistent with our approach at the urban and rural schools, all third-grade students in the sample schools were provided with questionnaires. The content of the surveys in the private migrant schools was identical to that of the rural schools.

4. Rural Minority Public School Data (Ethnic Minority Students)

The data on rural minority public schools come from Qinghai Province. Qinghai is a province in north-west China whose population has a high percentage of ethnic minorities relative to most other provinces in China. The minority population of Qinghai Province accounts for 47 percent of the total population (China National Bureau of Statistics, 2010). Tibetans account for 24 percent, Hui 15 percent, Tu 4 percent, and other ethnic groups, including Salar, account for 4 percent of the population. Qinghai Province is also the second poorest province in China.

The first step that we took to obtain the dataset on minority public schools was to select the prefecture and counties for our sample of rural public minority schools. Our survey in Qinghai Province was implemented in October 2011 in three counties in Haidong Prefecture. This prefecture has six counties within its jurisdiction. We chose Xunhua, Hualong and Huzhu counties in Haidong Prefecture as our sample counties because they are autonomous ethnic minority counties, primarily populated by four ethnic minorities

(Tibetans, Hui, Tu and Salar).

The sample of schools and students were drawn from a comprehensive list of all schools in the three counties. A project was run soon after the survey that focused on providing third and fourth-grade students with computer-based remedial tutoring in Chinese language and math in Tibetan communities. Because the level of Chinese language skills among Tibetan third and fourth graders was too low to make appropriate use of the computer-assisted learning program, we excluded these communities from the sample. From a subset of 52 rural minority schools (with Hui, Tu and Salar students) in the remaining three counties in our sample, we randomly selected 26 schools to be included in our final sample. In total, there were 2587 third and fourth-grade students in our sample of rural minority public schools.

As in the rural and private migrant schools, we included a block in our survey examining access to ICT. The survey questionnaires in Qinghai were identical to those in Shaanxi and migrant communities in Beijing.

5. Four School Types/Five Student Types

Table 1 summarizes the datasets for this study. The table includes summary information on the school type, the types of students in each type of school, the location of the sample, the number of sample schools and the number of sample students. In total, we surveyed 10 814 third, fourth and fifth-grade students in 150 elementary schools in Beijing, Shaanxi and Qinghai.

III. Results

In this section we present descriptive evidence on four different digital divides. The first subsection examines the urban–rural digital divide, the second subsection presents information on the rural–migrant digital divide, the third subsection describes the public migrant–private migrant digital divide and the fourth subsection surveys the Han–ethnic minority digital divide.

1. Urban–Rural Digital Divide

Our data show that although a digital divide between urban and rural students is present, it is not extreme (Table 2, rows 1 to 4). In urban public schools, 88 percent of students say that they use computers at school (column 1). Conditional on using computers at school, all students (100 percent) used the computers at least once per week and had 40 minutes or more of computer class time. Students reported that computer classes were never cancelled or replaced by non-computer classes. In other words, it appears computer class time in

Table 2. Descriptive Statistics Examining China's Urban–Rural Digital Divide among Urban and Rural Students in Beijing and Shaanxi, 2010

	Urban students in urban public schools (%)	Rural students in rural public schools (%)	Gap (percentage points)	Ratio (urban to rural)
In the school rooms of the students				
1. Use computers at school	88	69	19	1.3:1
2. For students that use computers at school, students have at least one computer class every week	100	72	28	1.4:1
3. 40 minutes or more per computer class	100	78	22	1.3:1
4. Computer classes, although scheduled, are frequently replaced by other courses	0	2	Almost equal	
What is learned in ICT class				
5. Learned how to turn the computer on/off	100	84	16	1.2:1
6. Learned how to use the keyboard	100	76	24	1.3:1
7. Learned how to use the mouse	100	80	20	1.3:1
8. Learned how to type Chinese	100	68	32	1.5:1
9. Learned how to draw	100	70	30	1.4:1
10. Used educational software	90	36	54	2.5:1
11. Learned about computer hardware	90	39	51	2.3:1
In the homes of the students				
12. Have some type of computer (e.g. laptop or desktop)	80	10	70	8:1
13. Can access Internet at home	73	5	68	14.6:1

Notes: See Table 1 for description of the data used in creating this table. ICT, information and communication technology.

urban public schools is quite regularized.

Although computer use by rural students is not as regular as that by urban students, the gap is relatively small (Table 2, rows 1 to 4, column 3). We find that 69 percent of rural students in our sample used computers at school. Of those that used computers at school, between 72 and 78 percent had computer class at least once each week, and these classes lasted at least 40 minutes. Computer classes in rural public schools were rarely cancelled: only 2 percent of the students reported frequent cancellations of computer classes.

In summary, the urban–rural digital divide (in the school rooms) is fairly modest in terms of the regularity of computer use (Table 2, rows 1 to 4, columns 3 and 4). When comparing the use of computers at school, the digital divide is only 19 percentage points wide, a ratio of 1.3:1. When comparing the regularity and frequency of computer classes, the gap is only 22 to 28 percentage points (ratios from 1.3:1 to 1.4:1).

When we examine skills learned in computer class, the story holds: the rural–urban digital divide is relatively modest (Table 2, rows 5 to 9). All urban students (100 percent) learn the basics of computer operation (e.g. how to turn the computer on and off and how to use the keyboard) (column 1). Most rural students (67 to 84 percent) learn these same skills (column 2). The gaps are between 16 and 33 percentage points (or ratios of 1.2:1 to 1.5:1).

However, the urban–rural digital divide widens when we examine whether students use educational software or learn about computer hardware (Table 2, rows 10 and 11). Ninety percent of urban students reported using educational or computer-assisted learning software in class (column 1), compared to 36 percent of rural students (column 2). There was a 54 percentage point gap (or ratio of 2.5:1) between urban and rural students (columns 3 and 4). Whether students learned about computer hardware, including the basic components of a computer and their purposes, was the source of another major gap (51 percentage points or 2.3:1 ratio: row 11).

The urban–rural digital divide widens even more when we examine student access to computers and the Internet at home (Table 2, rows 12 and 13). Eighty percent of urban students had access to computers at home, and 73 percent were able to access the Internet at home. In contrast, only 10 percent of rural students had access to computers at home (row 12), and only 5 percent of students could access the Internet (rows 13). The gap in ICT access at home varied from 70 to 68 percentage points (column 3), with ratios ranging from 8:1 to 14.6:1.

Taking these results together, we find that the urban–rural digital divide is modest at school, especially when examining the nominal use of computers (rows 1 to 4) and basic fundamentals of computer use (rows 5 to 9). However, the digital divide between urban and rural areas widens with the sophistication of ICT knowledge. Urban students in our sample were more likely to learn the rudiments of computer hardware and to use software to enhance education in other academic subjects. Most importantly, the digital divide is substantial in terms of access to computers and the Internet in student homes.

If the digital divide among school-aged children is a predictor of educational performance and employment opportunities later in life, the current magnitude of the identified digital divide may facilitate the persistence of China's rural–urban income gap.

2. Rural–Migrant Digital Divide

A question that arises when considering the rural–urban digital divide is whether rural children who move to or grow up in cities as migrant students enjoy increased access to ICT. Our data suggests that the answer is no: at least not completely. Both at home and in school, rural students have better access to ICT than migrant students enrolled in private

Table 3. Descriptive Statistics Examining China's Rural–Migrant Digital Divide among Rural Students and Migrant Students in Shaanxi and Beijing, 2010

	Rural students in rural public schools (percent)	Migrant students in private migrant schools (percent)	Gap (percentage points)	Ratio (rural to private migrant)
In the school rooms of the students				
1. Use computer at school	69	15	54	4.6:1
2. For students that use computers at school, students have at least one computer class every week	72	34	38	2.1:1
3. 40 minutes or more per computer class	78	54	24	1.4:1
4. Computer classes, although scheduled, are frequently replaced by other courses	2	20	–18	1:10
What is learned in ICT class				
5. Learned how to turn the computer on/off	84	71	13	1.1:1
6. Learned how to use the keyboard	76	62	14	1.2:1
7. Learned how to use the mouse	80	67	13	1.2:1
8. Learned how to type Chinese	68	56	13	1.2:1
9. Learned how to open/close a file	67	55	12	1.2:1
10. Used educational software	36	42	–6	1:1.2
11. Learned about computer hardware	39	42	–3	1:1
In the homes of the students				
12. Have some type of computer (e.g. laptop or desktop)	10	42	–32	1:4
13. Can access Internet at home	5	37	–32	1:7

Note: See Table 1 for description of the data used in creating this table.

migrant schools, whether at school or at home.

In terms of access to computers at school, students in rural public schools have an advantage over students in private migrant schools (Table 3, rows 1 to 4). According to our data, 69 percent of rural students use computers in school, compared to only 15 percent of migrant students in private migrant schools (row 1, columns 1 and 2). The gap is 54 percentage points, or a ratio of 4.6:1. This holds true when examining regularity of computer use and frequency of computer classes (rows 2 and 3). Conditional on access to computers, rural students take computer classes more frequently (72 *vs* 34 percent: a gap of 38 percentage points or a ratio of 2.1:1) and for longer periods of time per week (78 *vs* 54 percent: a gap of 24 percentage points or a ratio of 1.4:1) compared to migrant students in private migrant schools. Two percent of students in rural public schools report cancellations of computer class, compared to 20 percent of students in private migrant schools. In short, in terms of nominal use of computers, the rural–migrant digital divide is wide.

The digital divide appears to narrow somewhat when comparing the skills learned in rural schools to those in private migrant schools (Table 3). When asked about basic computer use, both rural students and migrant students report learning at approximately the same level (rows 5 to 9). The same is true when they are asked about "higher order" computer skills, such as use of educational software and knowledge of computer hardware. Interestingly, conditional on access to a computer class, migrant students have a slight, although not significant, advantage over rural students (rows 10 and 11). However, the unconditional statistics (including migrant students without school access to computers) reveal that rural students as a group have access to far better ICT educational resources than migrant students.

When looking at home computer usage, the direction of the rural–migrant digital divide is reversed (Table 3, rows 12 and 13). Migrant students are more likely to own a computer and to access the Internet at home than rural students. Our data show that 42 percent of migrant families, compared to 10 percent of rural families, own a home computer. Similarly, 37 percent of migrant students can access the Internet at home, compared to only 5 percent of rural students (row 13). The gaps are 32 percentage points or a ratio of 1:4 and 32 percentage points or a ratio of 1:7, respectively, in favor of migrant students. This suggests that residency in Beijing may stimulate computer purchases and Internet installation, even among migrants; however, we do not have information to definitively explain these observations. Possible reasons may be availability (Internet lines are more convenient to install in metropolitan areas such as Beijing), norms (it is more common, and, thus, more of a priority for households to own a computer in urban areas), income levels (migrant incomes are higher than those in rural households), or some combination of these factors and others.

In summary, the digital divide between rural students and migrant students in private migrant schools is nuanced. In terms of access to computers and skills learned at school, rural students in public schools have a considerable advantage over migrant students in private schools. However, migrant students are more likely to have access to a computer at home. In other words, while migration does appear to be associated with increased ICT access at home, migrant students attending private schools lack access to computers (and, more importantly, computer training) at school when compared to rural students.

Importantly, when compared to urban students in public schools, migrant students in private schools fall far behind in terms of ICT access. Is there any way that migration to urban areas can narrow the digital divide? Contingent on location and availability, some migrant students enroll in urban public schools. The next section explores the possibility that enrolling in public schools narrows the digital divide between urban and rural students.

3. Public Migrant: Private Migrant Digital Divide

Although it is clear that migrating to urban areas does not automatically eliminate the urban–rural digital divide, the experiences of migrants differ broadly. In particular, migrants attending private schools may have very different access to ICT compared to migrants in public schools. Our data allow us to compare access to ICT between migrants in urban public schools and migrants in urban private schools.

Using Table 4 (columns 1 and 2), we can compare access to ICT between urban students and migrant students enrolled in urban public schools. This comparison aids our understanding of the role that public schools play in providing access to ICT for migrant students (rows 5 to 13). We find that these groups have remarkably equal access to ICT. Because they attend the same school and same computer classes, the digital divide inside schools (almost by definition) is zero. More surprisingly, the digital divide at home is not wide either (80 – 70 = 10 percentage

Table 4. Descriptive Statistics Examining China's Public Migrant–Private Migrant Digital Divide among Migrant Students in Beijing, 2010.

	Urban students in urban public schools (%)	Migrant students in urban public schools (%)	Migrant students in private schools (%)	Gap (percentage points)	Ratio (public migrant to private migrant)
In the school rooms of the students					
1. Use computer at school	88	90	15	75	6:1
2. For students that use computers at school, students have at least one computer class every week	100	100	34	66	2.9:1
3. 40 minutes or more per computer class	100	100	54	46	1.9:1
4. Computer classes, although scheduled, are frequently replaced by other courses	0	1	20	–19	1:20
What is learned in ICT class					
5. Learn how to turn the computer on/off	100	100	71	29	1.4:1
6. Learned how to use the keyboard	100	100	62	38	1.6:1
7. Learned how to use the mouse	100	100	67	33	1.5:1
8. Learned how to type Chinese	100	100	56	44	1.8:1
9. Learned how to open/close a file	100	100	55	45	1.8:1
10. Used educational software	90	90	42	48	2.1:1
11. Learned about computer hardware	90	90	42	48	2.1:1
In the homes of the students					
12. Have some type of computer (e.g. laptop or desktop)	80	70	42	28	1.7:1
13. Can access Internet at home	73	58	37	21	1.6:1

Note: See Table 1 for description of the data used in creating this table.

points for computer ownership and 73 – 58 = 15 percentage points for Internet access: rows 12 and 13). These data suggest that one of the ways to narrow the digital divide in China is to ensure migrant students access to urban public schools.

We proceed to examine the digital divide between migrant students in urban public school and migrant students in private migrant schools. We refer to this as the public migrant–private migrant divide. When examining variables related to school computer use, the digital divide appears to be wide between these two groups (Table 4, rows 1 to 4). In urban public schools, 90 percent of migrant students say that they use computers regularly at school. Conditional on using computers at school, all students (100 percent) use the computers at least once per week and have 40 minutes of computer class time (column 1). Furthermore, computer classes are almost never replaced by other classes (1 percent of students report such occurrences). By contrast, computer access in private migrant schools is not regular (column 2). Only 15 percent of migrant students in private migrant schools report using computers at school. Of the students with any computer access, only 34 percent have computer class at least once each week, and only 54 percent report that classes, when held, are at least 40 minutes long. In addition, 20 percent of students with access to computers at school report that scheduled computer classes are frequently replaced by other classes (rows 1 to 4, columns 3 and 4).

The public migrant–private migrant digital divide is also wide when we examine skills learned in the computer classes. Although (conditional on attending a school affording access to computers) students in private migrant schools learn how to perform rudimentary functions at roughly the same rate as urban public schools (Table 4, rows 5 to 9), there is a wide public–private divide when comparing use of educational software and instruction on computer hardware (rows 10 and 11). Ninety percent of migrant students in public schools report using software that complements or enhances learning of core school subject matter, and learning about computer hardware in their computer classes. By contrast, fewer than half (49 percent) of migrant students in private migrant schools either use educational software or learn about computer hardware in school.

Finally, the public migrant–private migrant digital divide is also wide in terms of computer use and Internet access at home (Table 4, rows 12 and 13). Whereas 70 percent of migrant students enrolled in public schools have access to computers at home, only 42 percent of migrant students at private schools have access at home. Migrant students in urban public schools are also more likely to have Internet access at home (58 percent) compared to migrant students in urban private schools (37 percent).

In summary, the gap in ICT access between migrant students in urban public schools and those in private migrant schools appears to be substantial. Even though both groups of students have migrated from rural areas, students enrolled in public schools have as

much as six times more access to ICT in the classroom compared to students in private migrant schools. Moreover, students in public schools are far more likely to have computers and Internet access at home (when compared to students in private migrant schools).

Hence, although migrating from rural areas to urban areas does not always improve ICT access directly, those who can attend urban public schools have access that is comparable to urban students. For this reason we can say that schools appear to play an important role in determining whether students have access to computers, as well as the kinds of skills they learn in computer classes.

4. Han–Ethnic Minority Digital Divide

Ethnic minorities compose approximately 8 percent of China's population (China National Bureau of Statistics, 2007). It is possible that the language, culture and geographic isolation of many of these groups can prevent them from receiving the same access to ICT as their Han Chinese counterparts in rural public schools. In this subsection we examine the differences in access to ICT between students in rural public schools (in the Han-dominated province of Shaanxi) and rural minority students in rural minority public schools (in Qinghai Province). For brevity, we refer to this gap as the Han–ethnic minority digital divide.

In terms of access to ICT at schools, Han students have an advantage over their ethnic minority peers (Table 5, row 1). Whereas 69 percent of students in rural public schools reported using computers at school, only 16 percent of students in rural minority public schools had computer access (a difference of 53 percentage points). Conditional on having access to computers (rows 2–4, column 3–4), rural Han students are more likely to have computer class once per week (72 *vs* 16 percent: a gap of 56 percentage points). Compared to rural minority students, computer classes are more likely to last longer than 40 minutes (78 *vs* 16 percent: a gap of 62 percentage points). In addition, students in rural Han schools report fewer cancelled computer classes to those in minority schools (2 percent compared to 16 percent of classes cancelled). In sum, there is a wide Han–ethnic minority digital divide in terms of access to computers in schools.

When looking at the skills and knowledge learned in the ICT class (conditional on having regular computer class), the Han–ethnic minority digital divide widens (Table 5, rows 5 to 13). Regarding the acquisition of basic skills, the gap is quite wide. Only 16 percent of ethnic minority students are learning fundamental computers skills, compared to as high as 84 percent of Han students. The gap is also wide for higher order computer skills. While Han students report low levels of learning for these skills (36–39 percent), their rates are still well above those reported by ethnic minorities, which do not exceed 1 percent.

The Han–ethnic minority digital divide can also be found in home computer access. Whereas 10 percent of Han students have computers at home, only 6 percent of minority students in rural

Table 5. Descriptive Statistics Examining China's Han–Ethnic Minority Digital Divide among Rural Han and Rural Minority Students in Shaanxi and Qinghai, 2011

	Rural students in rural public schools (%)	Minority students in rural public schools (%)	Gap (percentage points)	Ratio (rural to rural minority)
In the school rooms of the students				
1. Use computer at school	69	16	53	4.3:1
2. For students that use computers at school, students have at least one computer class every week	72	16	56	4.5:1
3. 40 minutes or more per computer class	78	16	62	4.9:1
4. Computer classes, although scheduled, are frequently replaced by other courses	2	16	–14	1:8
What is learned in ICT class				
5. Learned how to turn the computer on /off	84	16	68	5.3:1
6. Learned how to use the keyboard	76	16	60	4.8:1
7. Learned how to use the mouse	80	16	64	5.0:1
8. Learned how to type Chinese	68	16	52	4.3:1
9. Learned how to open/close a file	67	16	51	4.2:1
10. Used educational software	36	1	35	36:1
11. Learned about computer hardware	39	1	38	39:1
In the homes of the students				
12. Have some type of computer (e.g. laptop or desktop)	10	6	4	1.7:1
13. Can access Internet at home	5	2	3	2.5:1

Note: See Table 1 for description of the data used in creating this table.

public schools do (row 12). Moreover, Han rural students are more likely to have Internet access (5 percent) than minority rural students (only two percent : row 13). Thus, we also find a digital divide between Han rural students and minority rural students in their homes.

In summary, even among rural populations, ethnic Han students have more access to ICT than ethnic minority students both in school and at home. When compared to ethnic minority students, Han students are more likely to have regular access to computers at school, to learn more skills, and to have greater access to computers and the Internet at home.

V. Discussion and Conclusions

In order to understand the nature and magnitude of the digital divide among different groups of elementary school students in China (which can help to predict tomorrow's employment outcomes and income inequality), we empirically examined three things: access to ICT in

schools, the quality and curriculum of ICT classes offered at schools, and access to ICT in the homes of students that attend the surveyed schools. Using our own data on more than 10 000 students in Beijing, Shaanxi and Qinghai, we measured gaps in access to ICT among four groups in China: the urban–rural, rural–migrant, public–private and Han–ethnic minority.

The results show that access to ICT is best among urban students. Urban students in urban schools are receiving almost 100 percent access to ICT in schools. They learn substantive computer skills, and have access to computers and the Internet at home. It is likely that these students will be prepared for the future workplace insofar as it requires an understanding of and facility with ICT.

Surprisingly, migrant students enrolled in urban public schools are not far behind. They differ from urban students only in their access to computers at home. Although they are rural-to-urban migrants, their experience differs greatly from migrants enrolled in private schools, whom our data show to have far less access to computers at school and who have learned few computer skills.

There is ambiguity about which group is next best off. Rural students in rural public schools have better access to computers and quality software at school than migrant students enrolled in migrant private schools. Migrant students have greater access to computers and the Internet than rural students at home. What is clear is that, compared to urban students, both groups lag far behind in access to ICT.

The worst in all categories are minority students in rural public schools. The greatest gap in access to ICT is between urban students and minority students. Indeed, the 80 percent to 6 percent (a 74 percentage point difference) gap in computer ownership and the 73 percent to 2 percent gap in Internet access indicate that the ratios for access to ICT at home range from 13:1 to 36:1. These results suggest that when compared to urban students, rural ethnic minorities may not have sufficient exposure and familiarity to ICT to compete in the future labor market.

What can be done about the digital divide in China? Two significant findings of the study point to a policy direction that might narrow the divide. First, being able to attend an urban public school effectively ensures access to ICT at school, as we have seen by comparing access to computers among migrant students in public or private schools. For this reason, one clear approach to narrowing the digital divide in urban areas could be to ensure access to public urban schooling for migrant students.

A second key finding is the low rate of ICT utilization in rural and, especially, ethnic minority areas. A large fraction of China's youth is still based in the countryside. Not providing equitable access to ICT resources likely puts these children at a significant disadvantage in the labor market when compared to their urban peers. Because the rural to urban migration trend in China is likely to continue, improperly prepared young people may find themselves at a loss in the labor market after arriving in the city. Investing further in ICT infrastructure in

rural schools and communities could do much to ameliorate this potential future imbalance.

Regardless of which policy direction policy–makers move toward, we believe the consequences of the digital divide are significant. Inequality in access to ICT has been shown to perpetuate inequality in standards of wellbeing. These income inequalities can undermine China's ability to upgrade its economy, sustain growth and expand prosperity. We therefore urge China's policy–makers to consider ways of providing equitable and quality access to ICT for students, regardless of whether they are migrants, from rural areas, or ethnic minorities.

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