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ABSTRACT

MACRO-GEOGRAPHIC LOCATION AND INTERNET ADOPTION IN POOR COUNTRIES: WHAT IS BEHIND THE PERSISTENT DIGITAL GAP?

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The paper investigates the determinants of Internet adoption in poor countries, focusing on the role of macro-geographic location (neighborhood). It is argued that neighboring countries are interconnected by various kinds of spillovers, including knowledge spillovers as well as spillovers of norms and attitudes that affect individual adoption behavior. The empirical findings support the view that Internet adoption is affected by adoption rates in neighboring countries, even when controlling for a wide range of covariates. Addressing potential endogeneity concerns using an instrumental variables approach moreover suggests these relationships to be causal. The findings imply that international policies to support Internet adoption in poor countries might be more effective if they target groups of neighboring countries rather than single countries in order to better exploit spillovers between neighboring countries.

Keywords: Internet adoption, poor countries, macro-geographic location, spillovers
JEL classification: O30, L96, R10

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1. Motivation

Digitalization is rewriting the rules of international competition, bringing about manifold opportunities for newcomers to enter global value chains and to catch up with incumbents. This applies not only to companies, but, in principle, also to countries. It is, however, by no means clear whether the digital revolution will help poor countries to better integrate into the global economy and to catch up in terms of income and wealth, or whether the rich countries will be able to sustain or even accelerate their competitive advantage by means of digital technologies (World Bank, 2016a).

The core enabling technology indispensable for reaping the fruits of the digital revolution is the Internet. Digital capabilities and, in particular, the capability to productively use the Internet increasingly determine which companies, industries and countries create or lose value (Hirt and Willmott, 2014; Capello and Nijkamp, 1996a, b). It is therefore of critical importance that developing countries swiftly abridge the digital gap that separates them from developed economies. Empirical reality looks different, however. As can be seen from Figure 1 and Table 1, the differential in Internet usage between developed and developing countries has in fact widened from 43.1% to 47.4% between 2005 and 2013.[1] The rise of the digital gap[2] is even more pronounced if one compares the developed countries with Africa, the poorest continent of the world (Table 1). Hence, contrary to the rosy picture of the Internet enabling new possibilities in communication and productivity in developing countries, the benefits from information technologies may be widening the chasm between richer nations and those that lack the infrastructure, skills and resources (Norris, 2001; Warf, 2001). "Access to the Internet is deeply conditioned by where one is" (Warf, 2001: 16), and there is little indication that the importance of geography is decreasing in the digital age. The point of the ICT-inequality nexus is well put by Rodriguez and Wilson who argue that "… when a new technology is introduced into a social setting where scarce resources and opportunities are distributed asymmetrically, the greater likelihood is that

those with more resources will employ them to gain additional one, including ICTs." (Rodriguez and Wilson, 2000: 11).

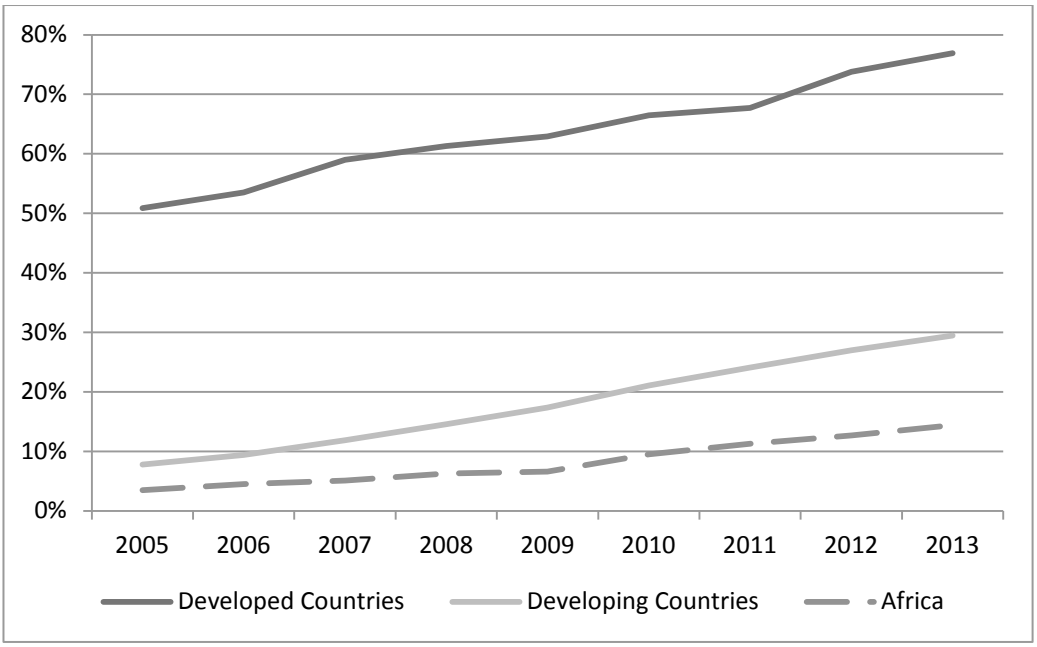

FIGURE 1. INTERNET ADOPTION RATES IN DEVELOPED AND DEVELOPING COUNTRIES 2005-20013
Source: ITU (2016), own compilation

TABLE1 1. DIGITAL GAP (IN PERCENTAGE POINTS) BETWEEN DEVELOPED AND DEVELOPING COUNTRIES

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Gap Developed– Developing	43.1	44.1	47.1	46.7	45.5	45.4	43.6	46.8	47.4
Gap Developed–Africa	47.4	49.0	53.9	55.0	56.3	57.0	56.4	61.1	62.5

Source: ITU (2016), own compilation

Moreover, access to the Internet is more multidimensional than adoption of telephones, televisions and radios in the past. The binary division of users and non-users only captures one facet of Internet access. DiMaggio et al. (2001) define the digital divide as "inequalities in access to the Internet, extent of use, knowledge of search strategies, quality of technical connections and social support, ability to evaluate the quality of information, and diversity of uses." Thus, the quality of use of the Internet will

also result in a second level digital divide amongst users (Hargittai, 1999), reiterating concerns that the lack of digitalization may further marginalize developing countries from mainstream economic growth (Davison et al., 2000).

Although there is a rich literature dealing with the determinants of Internet adoption and the digital divide (discussed in more detail in Section 2 of this paper), the possibility of cross-country interactions in the adoption process has grasped relatively little attention so far. The current paper contributes to a better understanding of the effects of macro-geographic location (and of urban structure within countries) on Internet adoption in poor countries. Our core hypothesis is that, apart from the usual suspects (including per capita income, telecommunications infrastructure, institutions), the neighborhood of a country, i.e. its macro-geographic location, has a crucial impact on the propensity of the country's population to adopt and productively use the Internet.

The paper is structured as follows: We begin with a brief review of the pertinent literature in Section 2 and develop our basic hypotheses in Section 3. Section 4 presents the data and introduces our empirical strategy. Section 5 presents and discusses the empirical results. Section 6 concludes and provides an outlook for policy and for future research.

2. Literature Review

The existing literature on Internet diffusion has established three main channels – economic, demographic and institutional – to attain widespread Internet diffusion. Unsurprisingly, economic variables, such as GDP per capita and telecommunication infrastructure, have been found to be key determinants of Internet diffusion in numerous studies (see, for instance, Andres et al. 2010; Wharf 2009; Wunnava and Leiter, 2008; Crenshaw and Robison, 2006; Beilock and Dimitrova, 2003;

Hargittai, 1999). Chinn and Farlie (2007) have analyzed the determinants of Internet penetration in a large cross section of countries and tried to decompose their relative importance. They found that the largest contributing factor to the Internet diffusion is per capita income, followed by per capita telephone lines. Kiiski and Pohjola (2002) examined the determinants of Internet hosts per 1000 inhabitants in 60 OCED and developing countries and found telephone access costs, income per capita and years of schooling to be significant determinants.

Other economic variables that have been investigated in different comparative studies include educational attainment, trade openness and telecommunication regulatory policies. Mixed conclusions have been found for these three variables, depending on the data used to measure them and on the empirical specification. Low levels or the lack of education are expected to hinder the accessibility and diffusion of the technology. In Kiiski and Pohjola's (2002) study of Internet diffusion in developing and OECD countries, average years of schooling significantly affected Internet diffusion positively, but telecom competition was found to be insignificant. Caselli and Coleman's study on computer diffusion found evidence that the attainment of secondary education and imports per worker strongly increases computer diffusion (Caselli and Coleman 2001). On the other hand, Chinn and Farlie (2007) and Hargittai (1999) have found no significant relationship between education and Internet diffusion, but highlighted the importance of telecommunication regulatory policy as a determinant of Internet diffusion.

Besides economic factors, a number of studies also investigated the importance of institutions in crafting and enforcing policies in ICTs advancement (see, for instance, Andonova and Diaz-Serrano, 2009; Wallsten, 2005). Andonova (2006) used three different measures of institutional quality, namely political rights, civil liberties, and political constraints, and their resultant effects on investment climate to explain differences in mobile phone and Internet usage, and found a positive relationship between institutional environment, infrastructural development and Internet usage. The risk of investment

expropriation was identified as the most important institutional parameter in fixed-line telecommunications development (Henisz and Zelner, 2001). Furthermore, countries with higher political freedom and better human and property rights protection tend to have higher Internet adoption rates (Crenshaw and Robison, 2006; Warf, 2009).

Demographic controls were also included in several studies of Internet diffusion since certain demographic characteristics are expected to push Internet adoption. Countries with greater urbanization and a younger population are expected to adopt the Internet more readily. Studies by Chinn and Farlie (2007) and Goldfarb and Prince (2008) hint at a positive impact of youth on Internet adoption, which is in line with findings from microdata (US Department of Commerce 2002). Results with respect to urbanization are less clear-cut, however. Chinn and Farlie (2007) find a significantly negative impact of urbanization (measured as the ratio of urban population in the total population), whereas other papers (e.g. Crenshaw and Robison, 2006 or Andonova, 2006) find opposite results. We argue that using a single urbanization variable – as is usual in the literature – might be inadequate and propose an additional measure to better reflect urban structure in Section 3.

3. The spatial dimension: macro-geographic location and urbanization

Although there is an extensive literature examining cross-country Internet diffusion, the role of macro-geographic location and the impact of neighboring countries on Internet adoption is not well explored as yet. This neglect is surprising as the importance of macro-geographic neighborhood effects is well established in the knowledge spillover literature (e.g. Keller 2002) as well as in Development Economics (e.g. Collier 2007). Moreover, the role of urbanization in Internet adoption in poor countries is still unsettled. The current paper addresses these apparent gaps in the literature. This Section puts

forward the theoretical argument, which is exposed to rigorous econometric analysis in the subsequent Sections.[3]

3.1 Macro-geographic location (neighborhood)

The majority of empirical work on Internet adoption has treated adoption units (countries) as independent and "… ignored the possibility of cross-country interactions in the adoption process" (Comin and Mestieri 2013: 29). There are, however, good reasons to assume that Internet adoption in a country is affected by Internet adoption in neighboring countries. As is well-established in the pertinent literature, spatial proximity facilitates the flow of knowledge. Spatial proximity (neighborhood) increases the likelihood of an encounter between inhabitants of country A and country B. The higher the share of Internet users in country A, the higher the likelihood that such an encounter will lead an inhabitant of neighboring country B to adopt the new technology. As Keller (2002) has shown, international technology diffusion is geographically localized, implying that neighboring countries tend to benefit more (in terms of productivity gains) from innovation in a given country than more distant countries.[4]

Knowledge spillovers might, however, be not the only relevant kind of spillovers between neighboring countries. According to the theory of planned behavior (Ajzen 1991), which has been widely and successfully applied to predict behavioral intention in technology acceptance,[5] an individual's behavioral intention in a specific context depends on three antecedents: attitude towards the behavior (ATB), subjective norm (SN) and perceived behavioral control (PBC). Attitude towards the behavior (in our case: attitude towards Internet adoption) reflects the individual's own (positive or negative) evaluation of the behavior in question. Subjective norm reflects an individual's perception that "most people who are important to him or her think s/he should or should not perform the behavior in

question" (Fishbein and Ajzen 1975, p. 302). Perceived behavioral control reflects an individual's perception of his or her ability to perform a given behavior.

All three antecedents of actual adoption behavior are context-dependent, suggesting that inhabitants of neighboring countries tend to be – ceteris paribus – more similar with respect to attitudes, subjective norms and perceived behavioral control than people from more distant countries. That people from neighboring countries often have very similar attitudes towards new technologies is well documented by cross-country surveys of attitudes and opinions towards science and technology in society (see, for instance, the Eurobarometer surveys on EU citizens attitudes towards science and technology in general (EU Commission 2014a, 2014b) or the Special Eurobarometers on public attitudes towards Internet use and data protection (EU Commission 2015), on biotechnology (EU Commission 2010) or on the use of robots (EU Commission 2012). A similar argument holds for norms and values.[6] As evidenced by the World Values Survey and related research (see, for instance, Parts 2013; Wach 2015 or Berggren and Nilsson 2015) social norms and values tend to be clustered in groups of neighboring countries. There is also some evidence of clustering across more distant countries that share a common history and language (e.g. the group of Commonwealth countries), but spatial proximity doubtlessly facilitates the spread of norms and values.[7]

The observed similarity of social norms and attitudes towards new technologies in neighboring countries is, however, by no means coincidental. As is well-known, peer groups and reference persons play an important role in the establishment of norms and in the forming of attitudes and intentions (Merton 1968; Venkatesh and Morris 2000, Falck et al. 2012).

Internet adoption might, however, not only depend on influential reference persons within a country. People might view the people of neighboring countries as a relevant peer or reference group. The reference group theory states that a reference group may mean a group with which one compares

oneself in making a self judgement (Merton and Kitt, 1950). Peer or reference groups might also serve as role models for individual behavior, such as Internet adoption. Although reference groups need not be restricted to neighboring countries,[8] spatial proximity is clearly helpful as common cultural and historical roots and common religious believes facilitate identification, and people have typically better knowledge of neighboring countries than of more distant countries. This is partly due to the fact that international migration is – to a substantial part – migration between neighboring countries. Moreover, identity economics captures the idea that people make economic choices not only based on monetary incentives, but also on their self-conception (Akerlof and Kranton 2000). Akerlof and Snower (2016) hint at the important role of narratives in motivating human action. As the spread of narratives is facilitated by geographic, cultural and language proximity it is plausible that neighboring countries have similar narratives that impact on norms, attitudes and believes and – finally – on behavioral intentions and actual behavior.[9]

The upshot of our argument is that there are manifold interactions between neighboring countries in the Internet adoption process. The impact of neighboring countries might go well beyond mere knowledge spillovers and take the form of cross-country spillovers of attitudes, norms and believes that impact on individual adoption behavior.

This leads us to hypothesis 1:

H 1: Internet adoption in a country is positively affected by Internet adoption in neighboring countries.

3.2 Urbanization

There are numerous studies suggesting that cities are the sites where economic, cultural and technical progress takes place (Hall, 1998; Feldman and Audretsch, 1999; Duranton and Puga, 2001). We might thus expect a positive relationship between urbanization and technology adoption. This view

reflects the so-called *urban density theory*, asserting that costs of Internet adoption are decreasing in population density and size due to knowledge spillovers and the availability of complementary infrastructure and inputs (Forman et al. 2005). The urban density theory is, however, not undisputed. A competing theory, known as *global village theory*, emphasizes the unique function of the Internet breaking down communication barriers between organizations, which implies that establishments in rural or small urban areas benefit most.[10]

As already discussed in Section 2, empirical evidence on the role of urbanization is ambiguous, in particular with respect to poor countries. In our view, this might be due to the fact that urbanization in poor countries is a mixed blessing. On the one hand, urbanization gives rise to agglomeration economies and can make Internet adoption more attractive due to lower (per capita) provision costs and the availability of complementary infrastructure and inputs. On the other hand, many cities in poor countries have seen a rapid, uncontrolled population growth in recent years, Today, among the approximately 500 cities in the world with more than 1 million inhabitants, about 70% are cities in the developing world that face very special problems, including massive congestion of infrastructure, shortage of housing and rapid expansion of 'urban poor' settlements (UN, 2015). 55% of the urban population in Sub-Saharan Africa lives in slums. The proportion is 31% in South Asia, 26% in East Asia and the Pacific, and 20% in Latin America (World Bank, 2015). Such settlements often fall outside of the normal provision of public amenities including supply of water, sanitation, sewage, and power (UNICEF, 2014). They face severe problems of overcrowding, pollution, crime and extreme poverty (UN, 2015), which are definitely not conducive to social and technical progress and likely to more than outweigh the advantages of urbanization.[11]

The variable most frequently used in the literature (the share of the population living in cities) captures both, the upsides and downsides of urbanization in poor countries, and it is thus not surprising that results are ambiguous. We retain this variable (in order to ensure comparability with previous work), but

also run alternative models making use of a variable (the share of population living in large cities with more than 1 million inhabitants) that better captures the peculiar problems of large urban agglomerations in poor countries. We expect the first measure (share of population living in cities) to have an ambiguous impact and the second measure (share of population living in large agglomerations with more than 1 million inhabitants) to have a negative impact on Internet adoption.

H2a: The share of population living in cities (urbanization per se) has an ambiguous impact on Internet adoption in poor countries.

H2b: A high concentration of population in large cities (more than 1 million inhabitants) has a negative impact on Internet adoption in poor countries.

4. Empirical Strategy and Data

4.1 Empirical Methodology

We build on existing models of Internet adoption and incorporate a location variable, $neighbor_{i,t-1}$, and an urbanization variable $urban_{i,t-1}$ in the cross-country analysis of Internet adoption. Our dependent variable, $user_{i,t,}$ is the percentage of Internet users in a country's population. Since technology diffusion is an accumulation of individual adoption decisions, the most relevant diffusion measure for most technologies is the ratio of actual to potential users (Andres et al., 2010).[12] The percentage of Internet users in a population is also one of most widely used measures in the literature (Chinn and Farlie, 2007; Andonova, 2006; Beilock and Dimitrova, 2003; Guillen and Suárez, 2005). Internet users is preferred over Internet subscribers and computer penetration rates, as it includes household access to the Internet, as well as Internet access from public places such as universities, workplaces and Internet cafes (Andres et al., 2010). As Internet adoption in developing countries is

only at a preliminary stage it typically follows a linear graph as can be seen from Figure A5 in the appendix. The graphs corroborate with the predictions of the S-shaped diffusion curve, with the state of Internet adoption in developing countries concentrated at the initial linear segment.

Our estimated model is as follows:

$$user_{i,t} = \alpha + \beta_1 neighbor_{i,t-1} + \beta_2 urban_{i,t-1} + \gamma' z + \alpha_i + \varepsilon_i$$

where α is a constant applied to all observations, $neighbor_{i,t-1}$ is the macro-geographic location (neighborhood) variable, $urban_{i,t-1}$ is the urbanization variable, Z is the set of control variables and α_i represents the unobserved heterogeneity (fixed effect) for each country. All independent variables and control variables are lagged by one year.

The location variable $neighbor_{i,t-1}$ is the main variable of interest and is constructed as the lagged average percentage of Internet users in neighboring countries. As discussed in Section 3, we consider two different measures of $urban_{i,t-1}$.The first measure of urbanization is defined as the proportion of the population living in cities (denoted as variable "*urban*") and the second measure defines urbanization as the proportion of population which lives in large agglomerations with more than 1 million inhabitants (denoted as variable "*urban_million*") . The control variables included in our empirical model, represented by Z, follow the previous literature on Internet diffusion (Section 2). These variables include measures of income (GDP per capita), telecommunication infrastructure, freedom of the press, days required to set up a business, years of schooling (as proxy for human capital quality), exports of goods and services, female labor force participation and population share of the elderly. We further control for unobserved, not time-varying heterogeneity across countries by estimating country fixed effects. A detailed description of all variables used in the empirical analysis is provided in Table A1 in the appendix. Table A2 displays the summary statistics.

An important assumption implicit in our estimation is the exogeneity of the regressors. While we have lagged the neighborhood variable by one time period, we cannot rule out the possibility of endogeneity and reverse causation. To take care of potential endogeneity of the neighborhood variable and allow for consistent estimation we perform instrumental variable (IV) regressions. We use past adoption of telephones – as measured by the average share of telephone fixed line subscribers from 1960 to 1995 in neighboring countries – as an instrument for Internet adoption in neighboring countries today, and denote this variable as "*neighbor (IV)*". In the 1960s, developing countries were at the initial stages of telephone adoption, similar to current Internet adoption levels (Brooks, 1976). While we can only instrument telephone subscribers in 5 years intervals due to data constraints, past variations in telephone subscribers remain a highly relevant instrument for variations in Internet users today.[13] The instrument (telephone subscribers in the past) is obviously not influenced by Internet adoption today, and the correlation between our main explanatory variable (the average share of Internet users in neighboring countries) and the instrumental variable (the average share of fixed line telephone subscribers in neighboring countries in previous periods) is high (above 73 %).

4.2 Data

Panel data on 63 developing countries on telecommunications and technology usage, country demographic and institutional characteristics have been compiled from 2005 to 2013. We follow the World Bank Country Classifications[14] in defining developing countries as low income and low-middle income countries. The full list of countries considered in our sample is displayed in Table A3 in the appendix. Data on telecommunications and technology use are obtained from the International Telecommunication Union. The main source of socioeconomic data, such as income, country demographics, and institutions, is the World Development Indicators (WDI) database by the World Bank. We also use indices of freedom of the press from Freedom House as a proxy for political

freedom. Our primary measure of human capital, average years of schooling, is derived from UNESCO Institute for Statistics. More details of the variables can be found in Tables A1 and A2 in the appendix.

As can be seen from Table 2, correlation between most explanatory variables is low. There are, however, two control variables (population share of older people and telephone fixed lines) which display levels of correlation larger than 0.5 with some of the other variables. We thus ran regressions excluding these two variables and found that this had no impact on the main results (reported in Section 5).

TABLE 2. BIVARIATE CORRELATION MATRIX

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Neighbor	1												
2	Neighbor (IV)	0.731	1											
3	Urban	0.465	0.376	1										
4	Urban_million	0.326	0.320	0.735	1									
5	Tel fixed lines	0.598	0.547	0.634	0.372	1								
6	GDP_cap	0.184	0.198	0.039	0.009	0.118	1							
7	Schooling	0.514	0.489	0.621	0.462	0.718	0.067	1						
8	Freedom of press	-0.067	-0.010	-0.261	-0.190	-0.011	-0.044	0.064	1					
9	Time to business	0.260	-0.094	-0.120	-0.063	-0.216	-0.026	-0.061	0.089	1				
10	Export	0.117	0.001	0.205	0.123	0.235	0.005	0.245	0.150	0.229	1			
11	Labor female	-0.212	-0.289	-0.372	-0.301	-0.310	-0.246	-0.083	-0.012	0.301	0.090	1		
12	Unemployment	0.089	0.231	0.223	0.161	0.251	-0.024	0.315	-0.038	-0.194	-0.173	-0.190	1	
13	Older than 64	0.610	0.512	0.592	0.351	0.897	0.098	0.769	-0.044	-0.156	0.207	-0.178	0.310	1

5. Findings

Table 3 displays the results of our baseline regression (with and without controls) and with two different urbanization measures. We find that Internet adoption in low and lower middle income

countries is positively affected by adoption rates in neighboring countries. This result is robust for different model specifications and also holds when we control for a rich set of other potential determinants of Internet adoption that have been discussed in the previous literature (columns 3 and 5 in Table 3).

TABLE 3. DETERMINANTS OF INTERNET ADOPTION RATES IN LOW AND LOWER MIDDLE INCOME COUNTRIES 2005-2013 (BASELINE ESTIMATIONS)

	(1) user	(2) user	(3) user	(4) user	(5) user
Neighbor	0.830***	0.753***	0.401*	0.939***	0.871***
	(0.142)	(0.160)	(0.222)	(0.205)	(0.207)
Urban		0.692*	-0.0942		
		(0.388)	(0.371)		
Urban_million				0.504	-0.614
				(0.807)	(0.539)
Tel fixed lines			0.0483		0.0951
			(0.170)		(0.215)
GDP_ cap			0.00757***		0.00497**
			(0.00218)		(0.00245)
Schooling			0.737		0.722
			(1.482)		(1.920)
Freedom of press			0.0694		0.177*
			(0.0722)		(0.0984)
Time to business			0.0108		0.00657
			(0.00862)		(0.0180)
Export			0.0623		0.103
			(0.0574)		(0.0714)
Labor_female			0.576		0.197
			(0.605)		(0.537)
Unemployment			-0.0717		-0.139
			(0.274)		(0.283)
Older than 64			-2.175		-3.569
			(2.844)		(3.206)
_cons	-0.903	-25.48*	-50.56	-9.542	-19.20
	(1.749)	(13.36)	(30.52)	(11.12)	(31.51)
N	464	464	382	305	247
adj. R^2	0.563	0.579	0.744	0.598	0.814

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Urbanization (as measured by the share of population living in cities) has an ambiguous impact on Internet adoption: The coefficient is positive (and weakly significant) in the model without controls, and negative and insignificant in the model with controls (columns 2 and 3 in Table 3). Using our preferred measure of urbanization in poor countries (share of population in cities with more than 1 million inhabitants) further increases the fit of the model,[15] but the urbanization variable remains insignificant (columns 4 and 5 in Table 3).[16]

While our results hint at a significant positive correlation of Internet adoption rates in neighboring countries, a causal interpretation is not possible as causality might run in both directions. In order to tackle the endogeneity problem we make use of an instrumental variable estimation. We instrument Internet adoption in neighboring countries with past telephone adoption in neighboring countries. As discussed in Section 4.1, the average share of telephone fixed line subscribers in neighboring countries (in 5-year intervals from 1960 to 1995) is a valid instrument, as it is clearly exogenous and highly correlated with our main variable of interest.[17]

As can be seen from Table 4, the results of the instrumental variable estimation confirm the results of the baseline model. We consider this strong evidence for the role of macro-geographic location (neighborhood) in determining Internet adoption rates in less developed countries. As discussed in Section 3, there are good theoretical arguments for an important role of neighboring countries. 'Good neighbors' create positive spillovers, and it is important to note that such positive spillovers go beyond knowledge spillovers in a narrow sense, but can also take the form of spillovers of attitudes and believes, brought about by role models from neighboring countries or the spread of social norms and narratives (characterizing risk-taking and technical progress as positive values) from neighboring countries. Our results are in line with recent anecdotal evidence provided by the World Bank: An example of a 'good neighborhood' noted by the World Bank is the group neighboring post-Soviet states, Kazakhstan, Kyrgyz Republic, Tajikistan and Uzbekistan. In recent years, there seems to be a contagion

effect in promoting ICT infrastructure in this region as neighboring countries began rolling out national infrastructure plans[18] successively after each other (World Bank, 2016b). A 'bad neigborhood', by contrast, is characterized by a lack of positive spillovers and a dominance of negative spillovers. Sub-Saharan Africa is a typical example of a 'bad neighborhood', with low income per capita, underdeveloped production structures, and poor human capital and physical infrastructure investments (World Bank 2016b), and it is notable that African countries such as Egypt and Swaziland have experienced slower growth in Internet adoption from 2005 to 2013 despite having higher GDP per capita than Bolivia and Guyana in South America.

TABLE 4. DETERMINANTS OF INTERNET ADOPTION RATES IN LOW AND LOWER MIDDLE INCOME COUNTRIES 2005-2013 (IV ESTIMATIONS)

	(1) user	(2) user	(3) user	(4) user	(5) user
Neighbor (IV)	1.084***	1.081***	0.928***	1.25***	1.225***
	(0.0505)	(0.0607)	(0.204)	(0.075)	(0.158)
Urban		0.0367	-0.204		
		(0.211)	(0.239)		
Urban_million				-0.411	-0.583*
				(0.468)	(0.305)
Tel fixed lines			-0.0649		-0.0273
			(0.116)		(0.130)
GDP_cap			0.00360**		0.00216
			(0.00183)		(0.00156)
Schooling			-1.743		-0.862
			(1.368)		(1.224)
Freedom of press			0.0791		0.188***
			(0.0500)		(0.0681)
Time to business			0.0172**		0.0127
			(0.00694)		(0.0152)
Export			0.0772*		0.106**
			(0.0446)		(0.0467)
Labor_female			0.478		0.156
			(0.339)		(0.300)
Unemployment			0.0654		-0.103
			(0.357)		(0.245)
Older than 64			-1.114		-3.124*
			(1.751)		(1.798)
N		437	353	300	237
adj. R^2		0.521	0.629	0.579	0.773

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 also shows a slight change in the results for the urbanization variables. The standard urbanization variable (share of population living in cities) is no longer significant, whereas our preferred urbanization variable (*urban_million*) has a negative impact on Internet adoption rates in poor countries and is significant in the model including further controls (column 5). As argued before, we consider this a plausible result, as rapid urban growth in the developing countries has outstripped the capacity of most cities to supply basic services for their inhabitants. The increasing local population and influx of migrants in cities in developing countries continue to exert pressure on the urban infrastructure and exacerbate the problems of urban congestion. (Cohen, 2006) These pressures and problems of urban congestion are often more severe in more populated cities, i.e. with a population of more than 1 million. Hence, extreme poverty of a large part of the population that excludes them from the information society in conjunction with the poor management of overcrowded cities that is hampering the provision of basic infrastructure and services are likely explanations for the negative correlation of 'urban million' with Internet adoption.

6. Conclusion and Outlook

Although there is a rich literature dealing with the determinants of Internet adoption and the digital divide, a pertinent factor, macro-geographic location, has been overlooked in the literature so far. A key finding of the current paper is that Internet adoption in low and lower middle income countries is positively affected by adoption rates in neighboring countries, even when controlling for a wide range of covariates (such as per capita income, telecommunications infrastructure, education or institutions). While 'good neighbors' create positive spillovers, and push Internet adoption, many of the poorest countries appear to be caught in a 'bad neighborhood trap', characterized by a lack of positive and a dominance of negative spillovers, and it is very hard for such countries to escape this trap on their own.

Own efforts of the poorest countries to improve their institutional settings, their education system and their analog and digital infrastructure are necessary, but they are unlikely to be sufficient. As the World Bank has concluded in its current World Development Report, "for digital technologies to benefit everyone everywhere requires closing the remaining digital divide, especially in Internet access", such that international policy action is indispensable (World Bank 2016a). Our results imply that international policies to support Internet adoption in poor countries might be more effective if they target groups of neighboring countries rather than single countries, as they can better exploit spillovers between neighboring countries. The same argument holds for development aid that might be more effective if it takes a broader view, and carefully takes the strong interrelation between Internet adoption in neighboring countries as evidenced by this paper into account. Moreover, appropriate policies to address the 'digital divide' should not only focus on availability and endowment (i.e. 'hardware' aspects), but also provide incentives for an interactive and creative use of the Internet throughout society (Camagni and Capello, 2005).

Our findings have important implications for research as well. The different forms of spillovers between neighboring countries are – due to their intangible nature – not well explored as yet. The analysis in Section 3 suggests that they might go beyond mere knowledge spillovers and can also take the form of cross-country spillovers of attitudes and believes brought about by role models from neighboring countries or the spread of social norms and narratives, which is clearly facilitated by spatial proximity. These forms of cross-country spillovers in technology adoption are not well captured by mainstream economics as yet. New approaches – such as identity economics – might be helpful in establishing a broader theoretical basis, allowing scholars to analyze spillovers between neighboring countries more thoroughly.

NOTES

[1] The developed/developing country classifications are based on the UN M.49 standard.

[2] The digital gap is measured as difference in the shares of Internet adopters in developed and developing countries.

[3] Unlike other studies on cross-country Internet adoption that take location into account (e.g. Forman et al. 2005), we are not focusing on commercial Internet diffusion, but aggregate Internet usage across countries.

[4] Keller finds that the distance at which the amount of spillovers is halved is about 1,200 kilometers.

[5] Liaw 2004, Brown and Venkatesh 2005, Pedersen 2005.

[6] Neighboring countries often share a common culture and language and a common (colonial) history. They tend to have similar religious and ethical beliefs and values and a similar view of the individual in society (individual versus collectivist societies).

[7] We are not aware of cross-country data for perceived behavioral control (reflecting such factors as self-efficacy and risk preference, but also resource and skill constraints that reduce a person's ability to perform a given behavior). It appears likely, however, that average perceived behavioral control tends to be similar in neighboring countries. Clearly, personal traits like self-efficacy and risk preference are not exogenous, but depend on the social environment in which a person grows up. As argued before, social norms and social environments tend to be more similar in neighboring than in distant countries. It is also plausible that the prevalence of restricting factors (resource and skill contraints) is similar in neighboring countries, as they are often at a similar development level and face similar social problems.

[8] They can also be made up of similar countries that do not necessarily have common borders.

[9] There is also a literature on 'social movement spillover', focused on how new social movements are influenced by existing movements and borrow from their strengths and strategies (Meyer and Whittier 1994). The events of the 'Arab Spring' provide evidence that social movements do not only spill over to other movements, but also to neighboring countries.

[10] The global village theory is thus better suited for commercial Internet adoption than for total Internet adoption that includes the adoption behavior of private households.

[11] Those who might benefit most from the Internet often have the least chance to use it. "Indeed, the 'information-poor' are typically unaware of the massive economic, technological and political changes that exclude them further from the 'information society' … " (Wharf, 2001: 12).

[12] Other Internet adoption measures in the literature include host counts, number of computers, broadband subscribers.

[13] Average telephone fixed lines subscribers in neighboring countries from 1960 to 1995 has an instrumental relevance test of F=69.70, which is highly significant.

[14] The World Bank classifies countries into low-income, lower-middle income, upper-middle and high-income groups according to their GNI per capita. As of June 2016, low-income economies are defined as those with a GNI per capita of $1,045 or less, whereas lower middle-income economies are those with a GNI per capita of more than $1,045 but less than $4,125.

[15] The adjusted R^2 increases from 0.744 to 0.814 in the models that consider control variables.

[16] The only significant controls are GDP per capita and freedom of the press. Both have the expected sign.

[17] First stage results of the IV estimation and results of the instrumental variable relevance test are shown in Table A4 in the appendix.

[18] Some examples of national infrastructure plans focusing on promoting ICT infrastructure are "Digital Kazakhstan 2020" in Kazakhstan, "Digital Kyrgyzstan 2020-2025" in Kyrgyz Republic, "National Development Strategy 2030" in Tajikistan, and "ICT Infrastructure Development Program 2015-2019" and "E-Government Development Program 2013–2020" in Uzbekistan.

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APPENDIX

TABLE A1. VARIABLE DESCRIPTION AND DATA SOURCES

Variable	Description	Source
User	Percentage of Internet users in a country	ITU
Neighbor	Average percentage of Internet users in neighboring countries	ITU
Neighbor (IV)	Average percentage of telephone fixed line subscribers from 1960 to 1995 (in 5-year- intervals) in neighboring countries	ITU
Urban	Urban population (% of total population)	World Bank
Urban_million	Urban population in agglomerations of more than 1 million (% of total population)	World Bank
Tel fixed lines	Telephone fixed-lines per population	ITU
GDP_cap	GDP per capita (PPP)	World Bank
Schooling	Average years of schooling	UNDP
Freedom of Press	Freedom of Press Ratings	Freedom House
Time to business	Number of calender days needed to set up a business	World Bank
Export	Exports of goods and services (% of GDP)	World Bank
Labor female	Female Labor force (% of total Labor force)	World Bank
Unemployment	Total unemployment (% of total Labor force)	World Bank
Older than 64	Population aged over 64 years old (% of total population)	World Bank

TABLE A2. SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
User	557	8.78348	9.966485	0.065239	56
Neighbor	472	12.17857	11.72404	0.255	57
Neighbor (IV)	445	2.191323	3.571777	0.0319996	26.80672
Urban	567	36.80471	14.61583	9.375	69.274
Urban_million	369	15.25189	8.519043	3.108902	46.82812
Tel fixed lines	554	4.852888	6.240416	0	30.64515
GDP_cap	558	3261.009	2320.175	530.9611	10580.9
Schooling	562	5.055872	2.643623	1.3	12.1
Freedom of press	567	58.903	16.7821	24	97
Time to business	519	37.9264	37.3605	2	260
Export	526	31.27736	15.39206	5.51685	87.06688
Labor_female	567	57.5381	18.38306	13.9	87.4
Unemployment	567	7.791711	6.397262	0.1	36.4
Older than 64	567	4.262633	2.472458	2.176046	16.13981

TABLE A3. LIST OF DEVELOPING COUNTRIES IN THE SAMPLE

Country	Country Code	World Bank Classification
Afghanistan	AFG	Low income
Armenia	ARM	Lower Middle Income
Bangladesh	BGD	Lower Middle Income
Benin	BEN	Low income
Bhutan	BTN	Lower Middle Income
Bolivia	BOL	Lower Middle Income
Burkina Faso	BFA	Low income
Burundi	BDI	Low income
Cambodia	KHM	Low income
Cameroon	CMR	Lower Middle Income
Cape Verde	CPV	Lower Middle Income
Chad	TCD	Low income
Central African Republic	CAF	Low income
Comoros	COM	Low income
Côte d'Ivoire	CIV	Lower Middle Income
Egypt	EGY	Lower Middle Income
El Salvador	SLV	Lower Middle Income
Ethiopia	ETH	Low income
Gambia	GMB	Low income
Georgia	GEO	Lower Middle Income
Ghana	GHA	Lower Middle Income
Guatemala	GTM	Lower Middle Income
Guinea	GIN	Low income
Guinea-Bissau	GNB	Low income
Guyana	GUY	Lower Middle Income
Haiti	HTI	Low income
Honduras	HND	Lower Middle Income
India	IND	Lower Middle Income
Indonesia	IDN	Lower Middle Income
Kyrgyzstan	KGZ	Lower Middle Income
Lao PDR	LAO	Lower Middle Income
Lesotho	LSO	Lower Middle Income
Liberia	LBR	Low income
Madagascar	MDG	Low income
Malawi	MWI	Low income
Mali	MLI	Low income
Mauritania	MRT	Lower Middle Income
Morocco	MAR	Lower Middle Income
Mozambique	MOZ	Low income
Myanmar	MMR	Lower Middle Income
Nepal	NPL	Low income
Nicaragua	NIC	Lower Middle Income
Niger	NER	Low income
Nigeria	NGA	Lower Middle Income
Pakistan	PAK	Lower Middle Income
Papua New Guinea	PNG	Lower Middle Income
Philippines	PHL	Lower Middle Income
Rwanda	RWA	Low income
Senegal	SEN	Lower Middle Income
Sierra Leone	SLE	Low income
Solomon Islands	SLB	Lower Middle Income
Sri Lanka	LKA	Lower Middle Income
Sudan	SDN	Lower Middle Income
Swaziland	SWZ	Lower Middle Income
Tajikistan	TJK	Lower Middle Income
Togo	TGO	Low income
Uganda	UGA	Low income
Ukraine	UKR	Lower Middle Income
Uzbekistan	UZB	Lower Middle Income
Vietnam	VNM	Lower Middle Income
Yemen	YEM	Lower Middle Income
Zambia	ZMB	Lower Middle Income
Zimbabwe	ZWE	Low income

TABLE A4: INSTRUMENT RELEVANCE TEST

VARIABLES	(1) Neighbor
Neighbor (IV)	0.850*** (0.102)
Telephone fixed lines	0.135 (0.112)
GDP_cap	0.00329*** (0.000748)
Schooling	5.64*** (1.28)
Freedom of press	-0.0165 (0.0522)
Time to business	-0.0101 (0.00887)
Export	-0.0389 (0.0347)
Urban	0.526** (0.213)
Labor_female	-0.381* (0.224)
Unemployment	-0.355** (0.175)
Older than 64	-3.03** (1.35)
Observations	353
Number of id	49
R-squared	0.703
Country FE	YES

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

F test of excluded instruments:

F(1, 293) = 69.70

Prob > F = 0.0000

Angrist-Pischke multivariate F test of excluded instruments:

F(1, 293) = 69.70

Prob > F = 0.0000

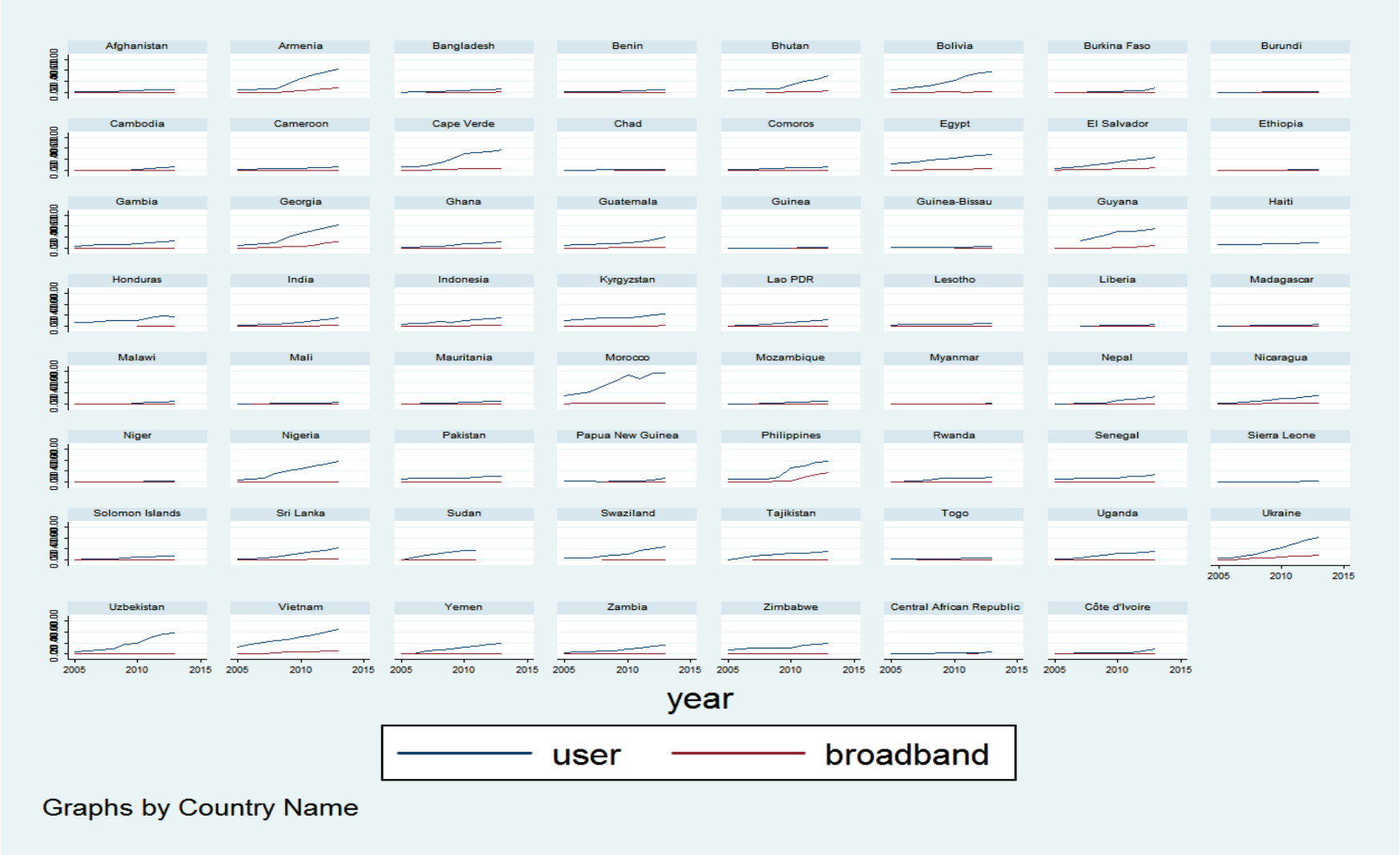

FIGURE A5. INTERNET ADOPTION IN 63 SAMPLE COUNTRIES FROM 2005 TO 2013 (Data Source: ITU).