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**A brave new geography of the Internet age? The determinants of
telecommunications growth in historical perspective**

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Abstract

The Internet is often portrayed as a novel, uniquely disembodied technology, floating free of territory and traditional place-based constraints. In this paper, we contribute to a growing body of literature which challenges such imagery. To do so, we use quantitative techniques to examine the determinants of spatio-temporal variations in the Internet and older communication technologies, namely, mail, the electric telegraph and telephones. Our results reveal striking similarities in the country-bound factors – income, education and trade openness – influencing rates of uptake. We conclude that, contrary to claims of novelty, the Internet is unfolding unevenly across geographic space according to conventional territorial and relational attributes.

Keywords. Global, Internet, econometric, digital divide, telecommunications, territorial

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'Prophets of a new cyberworld, like modernists before them, often overlook how much the new world overlaps and rests on the traditional world...' (Keohane and Nye 1998, 82)

Introduction

A recurrent narrative running throughout popular representations of the Internet is that it is somehow new. Hence the Internet is often portrayed as a uniquely emancipatory technology, capable of destabilising the existing patterns, constraints and significance of material geography (Kitchin 1998; Zook et al. 2004). Far from a simple linear progression, the Internet is seen as heralding a punctuated leap in the economic, political and social development of the modern world (Friedman 2005; Gates 1995; Negroponte 1998).

We do not deny the possibility that the Internet may have far-reaching consequences for material geographies. As elaborated by several economic geographers, new spatial and organisational opportunities opened-up by the Internet might be expected to generate new, or reinforce existing, territorially inscribed material geographies (Benner 2003; Gorman 2002; Graham 2002; Leamer and Storper 2001; Warf 2001). At the same time, research suggests that peoples' engagement with the World Wide Web may be instrumental in bringing into being new virtual and/or hybrid places (Holloway and Valentine 2001; Madge and O'Connor 2005).

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Yet we remain less convinced of claims about the supposed novelty of the Internet itself. We are not alone in our scepticism. A number of geographers have also questioned futuristic imagery of the Internet. Amongst others, they have challenged the idea of a uniquely disembedded, freely available and ubiquitous cyberspace, drawing attention to significant spatial variations in the distribution of the grounded material infrastructures and users that comprise the Internet (Bunnell 2002; Gorman and McIntee 2003; Graham 2002; Warf 1995, 2001; Zook et al. 2004). In fact, geographers have argued that the Internet exhibits strong continuity with past communication technologies (Malecki 2002). Thus, it is suggested that the Internet is developing along traditional fractures of wealth, institutions and structural relationships that influenced the uneven territorial development of past communication services (Graham 1998; Kitchin 1998; Warf 2001; Zook et al. 2004).

Our original contribution in the present paper is to empirically scrutinise this claim. Specifically, using large sample, econometric estimation techniques, we examine whether Internet usage is shaped by the same country-bound factors that governed the uptake of previous communication technologies, namely mail, telegrams and telephones. Recent cross-country studies have identified a number of domestic characteristics that influence the number of Internet users and/or hosts (Crenshaw and Robison 2006; Guillén and Suárez 2005; Kiiski and Pohjola 2002). Yet very little is known about the extent to which these territorial and relational attributes demonstrate continuity with older communication technologies. That is, is the Internet unfolding across geographic space according to the same country-bound factors as mail, telegraph and the telephone in the past?

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At the heart of this question is a wider debate about the extent to which modern information and communication technologies (ICTs) – of which the Internet can be seen as the high watermark – diminish the importance of place. According to many popular commentators (Cairncross 1997; Friedman 2005), they do. However, countering this position have been a growing number of geographers who have argued that, if anything, the Internet heightens the significance of place-bound characteristics (Agnew 2001; Graham 2002; Kelly 1999; Venables 2002). Our statistical results in the present study broadly lend empirical support to this latter argument. Hence we find that the uptake of the Internet is no less immune to country-bound attributes. Indeed, the growth of Internet users has been shaped by the same basic territorial and relational attributes – income, education and trade openness – that influenced the spatially and temporally uneven uptake of mail services, telegrams and telephones over the past century-and-a-half.

The rest of the paper is structured as follows. Part one briefly reviews recent debates about the territorial grounding of the Internet. Part two summarises previous cross-national statistical research concerned with explaining cross-national differences in Internet penetration, while part three speculates on the relevance of these determinants for the diffusion of previous communication technologies. Part four describes research methods and part five reports statistical results. Finally, part six concludes, and proceeds to discuss the wider implications of our findings.

Communicating across space and time

The Internet is the latest in a long line of space shrinking technologies that have been instrumental in reducing the friction of physical distance. Thus, postal mail, the electric telegraph and the telephone have all progressively reduced the time – and, equally important, the costs – of communicating over space, making it easier for actors to exchange information, co-ordinate activities and engage in various forms of commerce at a distance (Falk and Abler 1980; Harvey 1989; Held et al. 1999; Kellerman 1993). The Internet continues this trend, expanding the volume and diversity of data, information and services that can be conveyed across space, together with the ease, speed and efficiency of these transfers.

Yet, despite this obvious continuity, popular caricatures of Internet have persisted with the theme of novelty. Hence the Internet is often portrayed as a uniquely global communications network, capable of connecting people wherever they are. Accompanying such imagery is the idea that the Internet is somehow disembedded from everyday material worlds, floating free of territory, and escaping traditional place-based constraints (Hayes 1997).

For many geographers, however, such depictions are highly deceptive (Graham 1998; Warf 2001; Zook et al. 2004). They downplay the importance of supporting technological infrastructures required to participate in cyberspace. Moreover, popular representations of the Internet obfuscate how these networks of computers, wires and routers are physically embedded in specific places, and therefore neglect the ‘...ongoing

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importance of the material world' (Sassen 2002, 369). The Internet does not exist "out there", in other words, but "down here" in real material places (Bunnell 2002; Castells 1989; Kellerman 1993; Malecki 2002; Rutherford 2005; Sassen 2002). As such, the idea of a virtual, disembedded and ubiquitous Internet is more of a metaphoric construction, than a physical reality (Kitchin 1998).

Indeed, geographers have drawn attention to the highly uneven geographical distribution of material infrastructures required to access the Internet, as well as peoples' use of these infrastructures (Gorman and McIntee 2003; Warf 1995; Zook et al. 2004). Widely termed the "digital divide", such inequities in availability, access and usage have been identified at a range of geographic scales (Choi et al. 2006; Gibson 2003; Graham 2002; Malecki 2002; Perrons 2004; Warf 2001). However, it is disparities at the international scale that have captured the most attention, and which are the focus of the present paper.

Importantly, such spatial disparities call into question cyber-optimists' claims about the uniquely emancipatory and ubiquitous nature of the Internet (Kitchin 1998; Morgan 2004; Warf 2001). They show that the Internet is not, as is so often implied, 'anywhere and everywhere' (Graham 1998, 168). Instead, its availability and usage is highly uneven, with certain places more densely connected to cyberspace than others. Moreover, and of special salience here, geographic disparities serve as a salutary reminder of continuity. In particular, to the extent that past communications media such as mail, telegraph and the telephone similarly diffused unevenly across space and time, they show that the Internet may not be so novel after all (Buchner 1998; Comin and Hobijn 2004; Kellerman 1993; Mitchell 2003; Osborne and Pike 1991; Standage 1998).

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According to several observers, such similarities are hardly surprising. In common with past communication technologies, the Internet is being deployed in a world of geographically uneven wealth, diverse institutional traditions and structural relationships (Gillespie and Robins 1989; Kitchin 1998). And it is spatio-temporal variations in these attributes, rather than some technologically determined pathway, that shapes ‘the way in which people and place become “wired” (or remain “unwired”)’ to the Internet’ (Zook et al. 2004, 156). Indeed, it is our contention that the country-bound attributes influencing uptake of the Internet are likely to be similar to those shaping the spatially uneven growth of past communication technologies.

Correlates of the Internet’s space of places

This idea that the domestic grounding of the Internet is shaped by territorial and relational attributes is supported by recent statistical research. According to these studies, cross-national differences in Internet access and/or usage can be explained by a combination of contextual variables. By far the most important of these is wealth which emerges as a positive correlate of Internet hosts and/or users across a range of developed and developing country samples (Baliamoune-Lutz 2003; Bauer et al. 2002; Crenshaw and Robison 2006; Guillén and Suárez 2005; Hargittai 1999; Kiiski and Pohjola 2002; Oyelaran-Oyeyinka and Lal 2005).

The importance of wealth is perhaps unsurprising. Connecting to cyberspace is capital-intensive requiring, amongst others, substantial investments in wires, routers and hubs (Harwit 2005). Because of the “lumpy” nature of these investments, capital poor

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developing economies have often struggled to establish and/or expand Internet access (Xue 2005). Compounding these supply-side constraints are demand-side ones with low income users less able to afford access charges and/or the electronic equipment required to interface with the Internet.

While income explains a large amount of cross-national variability, it is not the only factor. The literature identifies four others. One of the most widely studied is human capital. Thus, a large number of studies have found that levels of education exert a positive influence on domestic uptake of the Internet (Andonova 2006; Balamoune-Lutz 2003; Dewan et al. 2004; Liu and Gee 2006; Quibria et al. 2003). Again, this makes sense. Activities such as email, online chat and Web surfing require linguistic and computer literacy, which are likely to be found in greater abundance in better educated countries. In fact, because well educated users are better placed to fully exploit the commercial, leisure and learning opportunities provided by the Internet, it follows that demand should be greater in economies with higher levels of human capital.

Institutional quality is another attribute affecting uptake of the Internet (Andonova 2006; Crenshaw and Robison 2006; Guillén and Suárez 2001; Hargittai 1999; Liu and Gee 2006). Its significance in the present context is widely attributed to the influence of a country's legal, political and regulatory environment over investment decisions (Henisz and Zelner 2001). Where the institutional environment provides stable, secure and credible conditions for investment, and therefore assured returns, it follows that investors should be more willing to make capital outlays in telecommunications infrastructure. Conversely, in countries characterised by regulatory instability, corruption

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and the risk of expropriation, it is perhaps understandable that investors should be less likely to respond to market demand for new and/or expanded Internet connectivity.

A third variable is trade. The importance of trade has been identified in countless studies concerned with the international diffusion of new industrial technologies (see Perkins and Neumayer 2005), and indeed, several studies which have examined uptake of the Internet (Baliamoune-Lutz 2003). Trade potentially increases the supply of new technologies, either directly via physical imports, or indirectly via technological spillovers. In doing so, it can lower the costs of new innovations, thereby increasing uptake by potential adopters. By enhancing competition in domestic markets (from imports) or foreign markets (for exporters), trade also increases the demand for new productivity-enhancing technologies (Saggi 2002). Finally, international trade is believed to stimulate mimetic dynamics, as domestic actors emulate investments made by their counterparts in countries with which they trade, whether for rational or non-rational (i.e. legitimacy) motives (Perkins and Neumayer 2004). In reality, surprisingly little is known about the operation of these mechanisms, although it is possible that all explain the catalytic role of trade on domestic Internet connectivity.

Finally, a number of studies have identified a role for domestic telecommunications policy. In particular, regulations fostering greater competition between service providers – for example, through mandatory unbundling and access to the local loop – have been identified as a positive correlate of Internet diffusion (Bauer et al. 2002; Guillén and Suárez 2005; Hargittai 1999). Most likely, this is because competition stimulates improved Internet services, functionality and lower costs for users, increasing uptake amongst potential adopters.

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In sum, there is ample empirical evidence that cross-national variations in uptake of the Internet are influenced by the economic, institutional and relational attributes of the domestic context. The Internet is not exempt, in other words, from the tyranny of material geography. Its territorial presences and absences continue to be shaped by country-bound material conditions.

Plus ça change?

The central question addressed in the present paper, however, is whether these material attributes similarly influenced the uneven geographic uptake of past communication technologies. At a conceptual level, the case for continuity is compelling. Thus, technologies such as mail, telegraphy and telephony exhibit many of the same structural characteristics as the Internet. In common with the latter, they comprise complementary networks of physical artefacts, supporting infrastructures and users. Moreover, the grounding of these elements in place-based contexts is likely to have similarly depended on domestic demand and supply side factors. Included are the hardware and software required to make the technology function, as well as the ability, willingness and motivation of potential adopters to make use of communications services.

Accordingly, it makes sense that income should have played an equally pivotal role in influencing the domestic uptake of previous communications innovations. Providing mail, telegraphy and telephony services, for example, will have similarly necessitated capital-intensive infrastructural investments (Willmore 2002). Access to these services will have also depended, to a greater or lesser extent, on the ability of

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potential adopters to afford user charges. Indeed, to the extent that GDP per capita is one of the most statistically robust predictors of innovation diffusion (Rogers 1995), it would be truly surprising if it did not positively influence the usage of previous telecommunication services.

Similarly, it is entirely plausible that cross-national disparities will have been shaped by human capital. As with the Internet, demand for past communication services is likely to have risen with education, with more educated citizens better able to use communication services. A well educated population is also likely to have supported the effective and efficient installation, operation and maintenance of communication systems, facilitating their expansion.

Investments in capital-intensive infrastructures such as the electric telegraph and telephone services are also likely to have been sensitive to the domestic regulatory, legal and political environment. In much the same way as the Internet, the existence of weak, unstable and/or corrupt political institutions would plausibly have hindered the willingness of private actors to invest, retarding the expansion of new communications infrastructure. Similarly, the importance of long-distance communication technologies in facilitating the international exchange of goods and services means that their uptake is likely to have been greater in more trade-based economies. Trade is also likely to have been instrumental in spreading knowledge about the adoption of communication technologies in other countries (Standage 1998). Indeed, it is quite possible that governments and firms in countries more open to trade will have sought to protect and/or advance their competitive position by supporting the development of communication infrastructures, resulting in faster rates of growth.

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Of course, the ultimate arbiter of whether the geographic determinants of the Internet and earlier communication technologies are similar is empirical study. There is some existing evidence of continuity. Quibria et al. (2003) and Torero et al. (2006), for example, find a positive relationship between GDP per capita and the number of telephone mainlines. Henisz and Zelner (2001) show that institutional quality has a negative influence on the uptake of digital telephone infrastructure. Similarly, Quibria et al. (2003) find that more educated countries have more telephone mainlines, while Perkins and Neumayer (2005) estimate a positive relationship between levels of trade openness and the uptake of digital telephony.

Yet these studies hardly constitute a robust empirical test of continuity. They are far from comprehensive, examining only a scattering of communication technologies and determinants. Moreover, using different definitions, methodologies and samples, it is difficult to know how to interpret these findings, or determine the extent to which they are comparable. What this suggests is the need for a more comprehensive and methodologically consistent analysis. In the present paper, we seek to undertake such an analysis, using panel data on mail, telegram, telephone and Internet uptake.

Consistent with the majority of past research which has examined cross-national variations in the growth of communication technologies, we use econometric estimation techniques. By doing so, we inevitably sacrifice the sort of rich, nuanced and institutionally “thick” detail afforded by qualitative research. Yet we believe that a quantitative approach is especially well-suited to the present research context. Specifically, by allowing us to investigate a large number of cases, and control for the

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influence of competing variables, we are able to examine the explanatory significance of several hypothesised determinants across a range of technologies, countries and years.

In the next section, we discuss our research methodology in greater detail, beginning with our choice of dependent variables.

Methodology

Historical analyses of technological diffusion raise many challenges. For a start, the availability of internationally comparable data is limited, restricting the choice of variables. Moreover, where data are available, they are more likely to contain measurement error than contemporary datasets. As a result, it becomes difficult for variables to assume statistical significance at conventional levels. These caveats should be borne in mind when interpreting our findings. Still, we believe that we have assembled the best available data, and moreover, that our econometric estimations capture genuine determinants of technological diffusion.

Dependent variable

Our dependent variables in the present study are the annual growth rates in a country's per capita uptake of mail, electric telegraph, telephone and Internet services. Ideally, we would like to use an identical flow measure of usage for all four technologies. This is possible for mail and telegrams, for which we have data on the number of mail items and telegrams sent, both on a per capita basis. Along similar lines, we are able to deploy a

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usage metric for the Internet, albeit one that measures numbers of Internet users per capita, rather than actual levels of usage (e.g. number of hours online, kilobytes sent). For telephones, on the other hand, we are forced to use a stock measure of infrastructure, in the form of numbers of telephones per capita. Needless to say, we would have preferred to use exactly the same measure across the four technologies. However, data limitations mean that this was simply not possible, and in any case, we believe that all four measures broadly capture similar dynamics.

Data for our dependent variables are taken from Mitchell (2003) in the case of mail, telegram and telephone, and from World Bank (2005) for the Internet. The former provides statistics on mail and telegraph usage as far back as 1830 and 1850, respectively, but comprehensive trade data are unavailable before 1870, so our panel starts with this year. Data on Internet usage are available from 1991 and, at the time of writing, ran until 2003, which is the final year of our panel.¹ Countries enter and – occasionally – exit (e.g. during times of war) the dataset according to the availability of data. Our panel is therefore “unbalanced”, but the random- and fixed-effects panel estimators used in the present study are able to accommodate such data.

Before proceeding, it is worth briefly explaining our choice of technology cases, and their chronology. First and foremost, postal mail, the electric telegraph and the telephone were selected because of their historic role in communicating. All three technologies have – to a greater or lesser extent, and for longer or shorter periods of time – assumed central importance in allowing actors to communicate over space. They were

¹ The telegraph is the only technology in our study that has become obsolete. Since we are only interested in the determinants of uptake growth, we restrict our analysis to the period before 1970, during which time the number of sent telegrams is expanding in the vast majority of countries. After this date, telegraph usage begins to decline, sometimes quite dramatically. In fact, many countries stopped reporting statistics on telegram usage in the 1980s.

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also chosen because, although not always strictly functionally equivalent, each of the subsequent innovations offers improved functionality over earlier equivalents. This is important to the extent that it establishes continuity with the Internet, which can be conceived as just the latest in a line of technologies with greater communicative capabilities.

Briefly, the history of the above communication technologies can be summarised as follows. Systems for sending items of mail within and across national borders have existed as far back as antiquity. Yet it was not until the first half of the nineteenth century that modern, pre-paid and publicly accessible postal services began to operate, many of them as public monopolies (Willmore 2002). Postal mail was joined in the second half of the nineteenth century by the electric telegraph. The telegraph was ground-breaking in its capacity to rapidly convey information over space, eventually revolutionising long-distance communications (Standage 1998). Yet limited bandwidth and comparatively high user costs meant that the telegraph did not substantially challenge the dominance of mail for domestic and international communications (Kielbowicz 1987).

The next globally significant communication device, the electric telephone, first emerged in late 1870s. Once again, the telephone opened-up new communication opportunities, allowing the near instantaneous transmission of voice traffic. Much like the electric telegraph, however, high costs and technical constraints restricted its uptake (Willmore 2002). Only during the second half of the twentieth century did telephones become more widely used outside the core of high income, industrialised economies (Guillén and Suárez 2005).

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The Internet continues this lineage. Although originating in the late 1960s and 1970s in university and military settings, it was not until the early 1990s that the Internet began to be adopted by a wider range of consumer, business and governmental actors. It has subsequently diffused rapidly, such that the majority of the world's countries are now "online". Still, despite becoming one of the fastest diffusing technologies in human history, the density of hosts, connections and users remains highly uneven.

Independent variables

Four explanatory variables are included in the present study: GDP per capita, education, institutional quality and trade openness. These variables were selected, first and foremost, because they have all been identified in recent empirical studies as correlates of national Internet availability, access and/or usage. What is more, data with suitably wide cross-country and temporal coverage exist for each of the explanatory variables.

Data for our first variable, GDP per capita, is taken from Maddison (2003). In accordance with previous studies of technological diffusion (Perkins and Neumayer 2005), we take the natural log of per capita income. Our second explanatory variable is human capital. Unfortunately, we can use neither our preferred, nor an identical, proxy of human capital. Our ideal metric would be some measure of secondary school education. Yet historical statistics for many countries only report data on general schooling and it is unclear whether these capture actual levels of secondary education in any meaningful way. We therefore resort to tertiary or university/college education. In the case of the Internet, we take the tertiary enrolment ratio, using data from World Bank (2005). These

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data only cover the period from the 1960s onwards and we therefore use Mitchell's (2003) data on the number of university students per capita for mail, telegrams and telephone. For the overlapping period, the two measures of education are very highly correlated at 0.84, suggesting that they capture the same underlying concept.

Our third variable is institutional quality. For recent periods, there are a number of different measures of institutional quality. However, there is only one that reaches far enough back into the past, namely Henisz's (2000) metric of political constraints. It measures the extent to which political actors are constrained in their future policy choices by the existence of other political actors with veto power, and by the distribution of political preferences across and within these branches of the political system. In other words, it captures the degree to which governments are able to credibly commit to maintaining an existing regulatory regime. The greater the constraints faced by policy makers, the more security, stability and regulatory continuity both domestic and foreign investors can expect, thereby reducing investments risk. Henisz's data have been used to measure institutional quality in previous studies investigating the uneven diffusion of telecommunication technologies (Andonova 2006; Henisz and Zelner 2001). Our fourth variable, trade openness, is given by the share of trade in GDP. For the Internet, we use data from the World Bank (2005). However, because these data do not stretch far back in time, we construct a measure of trade openness for our three historical technologies using data from Barbieri (1998) and Maddison (2003).

While we explore the influence of GDP per capita, human capital, institutional quality and trade on the growth of mail, telegrams and telephones, we do not investigate

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the role of telecommunications regulatory policy. The reason is that we simply have no data for competition and other policies governing mail, telegram and telephone markets.

Dealing with statistical problems

The panel data used in the current study throw up a number of potential problems for statistical estimation. At the same time, however, they offer several solutions for overcoming these problems. One challenge is how to deal with the fact that uptake of new technological innovations characteristically accelerates over time, as they benefit from increasing returns to adoption (Rogers 1995). Within the present study, we control for these temporal dynamics by including year-specific time dummies, which potentially capture global changes in the availability, cost and functionality of any one technology that affect all countries equally.

We additionally include the natural log of the per capita technology uptake, lagged by one year. There are two reasons for its inclusion. The first is to control for conditional convergence. The rate of diffusion of many technologies is influenced by the existing levels of penetration, in that countries with higher levels of uptake characteristically experience slower uptake growth (Henisz and Zelner 2001; Perkins and Neumayer 2005). The telecommunication technologies examined in this paper are no exception.

We also include the lagged log of technology uptake to control for autocorrelation in the error term (Beck and Katz 1996). The growth rate is equivalent to the natural log of a variable minus its natural log one previous period. Hence regressing the growth rate on

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the log-level lagged by one period is equivalent to regressing the log-level on the lagged log-level. The only difference is that the estimated coefficient of the growth rate equation is that of the log-level equation minus one. What is important here is that the inclusion of what is effectively a lagged dependent variable allows us to indirectly control for autocorrelation.² We employ standard errors that are robust to arbitrary heteroscedasticity to deal with the other common problem of statistical inference.

The one potential statistical problem for which we cannot offer a satisfactory solution is reverse causality. That is, while income, trade, education and institutional quality are likely to shape the uptake of telecommunication technologies, uptake might in turn influence income, trade, education and institutional quality, if only in the intermediate to long run. The only convincing approach to deal with such potential endogeneity is through the use of instrumental variables. However, it is impossible to find valid instruments in the present context, not least because many of the variables are functionally related. In their absence, we have to acknowledge that technology and its material determinants co-evolve over time to some extent, a point recognised in several recent contributions (Warf 2001). Still, we believe that the chief direction of causation is from the material determinants to technological adoption, and not the other way around.

² The inclusion of a lagged dependent variable introduces some bias into the estimations, which is known in the literature as Nickell (1981) bias. However, this bias diminishes as T, the time period covered by the estimations, increases. Since, with the exception of our Internet estimations, T is very large indeed, we can neglect this bias.

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Estimation technique

Panel data – of the sort used in the present paper – is typically estimated with either a random- or a fixed-effects estimator. The advantage of the random-effects estimator is that it is more efficient. This is because estimation is based on variation over time within countries, as well as on variation across countries. The country fixed-effects estimator, on the other hand, exclusively uses the within- or over-time variation in countries. Such fixed-effects estimation is particularly inefficient for explanatory variables that change little over time. The disadvantage of a random-effects estimator is that it produces inconsistent estimates if the country-specific effects are systematically correlated with one of the explanatory variables. A compromise between the random- and the country fixed-effects estimator – a so-called regional fixed-effects model – is achieved by including regional- rather than country-specific fixed effects.

In the next section, we report random-effects and regional fixed-effects estimation results. We use the World Bank's (2005) classification of countries into regions of North America, Latin America and Caribbean, Western Europe, Eastern Europe and Central Asia, North Africa and Middle East, Sub-Saharan Africa, South Asia, and East Asia and the Pacific. In the appendix, we additionally report country fixed-effects estimation results.

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Results

Table I reports our random-effects estimation results. We start with the Internet. GDP per capita, education, trade openness and institutional quality are found to be positive and statistically significant correlates of domestic growth in Internet users. Of note, these results are consistent with past empirical research.

Across all four technologies, we also we find that countries with a higher level of penetration in the previous year experience lower growth rates, a phenomenon well-documented in the innovation diffusion literature (Perkins and Neumayer 2005).³

Table I around here

Of greater interest – and largely unexplored in past research – is the question of whether the determinants of uptake growth for our three historic communication technologies match the Internet's. In the case of wealth, we find similarity with telegrams and telephones. Thus, GDP per capita is positively and statistically significantly correlated with the uptake of both technologies. This is entirely plausible. In common with the Internet, telegraphy and telephony involve large, and to a greater or lesser extent, lumpy capital investments. Moreover, since these costs must be recovered, uptake is likely to have depended on the ability of consumers to afford user charges. Indeed, our finding is consistent with previous research into the geographic spread of more advanced telephony technology (Henisz and Zelner 2001; Perkins and Neumayer 2005).

³ The coefficient sizes should not be compared with each other across the technologies. The samples are too different, particularly with respect to time, for such a comparison to make sense.

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Turning to human capital, we find that the number of university students is positively and statistically significantly correlated with mail volumes, telegrams sent and telephones per capita. Again, this makes sense. Installing, maintaining and operating communication systems require adequate knowledge, skills and expertise. Equally, demand for these communications media is likely to have been shaped by levels of human capital, with more educated users better placed to make greater use of mail, telegraph and telephony.

Yet our measure of institutional quality appears to have no statistically significant influence on any of the three historic communication technologies. Coefficients for mail, telegrams and telephones fail to achieve statistical significance at the 10 percent level. At first glance, these findings are counter-intuitive, contradicting conventional wisdom about the importance of institutional quality on large infrastructural investments. However, they might simply reflect the leading role played by the private sector in financing Internet growth. Although mail, telegraph and telephone systems often began their life in the private sector, a large share of investments in expanding these systems were subsequently made by public actors (Willmore 2002). And because private actors are likely to be more sensitive to domestic factors influencing investment returns, differences in ownership provide a possible explanation for this anomalous result.

Finally, for trade openness, we find consistency throughout. As with Internet users, mail items, telegrams and telephones per capita are all positive and statistically significant correlates of a country's share of trade in GDP. Unfortunately, our statistical findings say nothing about the channels by which trade catalyses uptake, although the literature identifies a number of possible candidates (Gertler 2001; Guillén and Suárez

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2005; Perkins and Neumayer 2004). First, by exposing firms to greater competition, domestic imports and exports might stimulate demand for productivity-enhancing communication technologies. Higher levels of trade are also likely to expand demand for communication technologies to the extent that it implies the need for increased long-distance transactions between actors in different countries.

International trade additionally potentially supports cross-country learning, comparison and emulation. Thus, actors in countries more open to trade are more likely to learn about the benefits of new communication technologies, as well as the diversity of uses to which they can be applied. Indeed, higher levels of international exposure through trade could simulate comparison with more technologically “progressive” countries, prompting domestic actors – and governments and larger firms in particular – to adopt communication technologies in order to “keep up with the Jones’s”.

In table II, we trade-off some efficiency for potential gains in consistency of estimations by including regional fixed-effects into the model. As can be seen, doing so changes our results only slightly. The main difference is that the positive coefficient for GDP per capita in the case of mail items, which was insignificant in random-effects estimation, now becomes clearly statistically significant, providing further evidence for the role of GDP per capita in historical communications technology uptake.

Table II around here

The appendix trades-off efficiency versus potential consistency gains further by providing country fixed-effects estimation results for all four technologies. For the three

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historical technologies, the results are broadly in line with the random-effects estimation results. That some variables become insignificant – for example, education in the case of mail and telephones – is only to be expected, given the relative inefficiency of the country fixed-effects estimator.⁴

In the case of the Internet, however, there is a dramatic difference between the random- and the country fixed-effects results. All of the explanatory variables, other than the existing uptake level, are statistically insignificant in this specification. How might we explain this discrepancy? Have previous studies, which have similarly identified income, education, institutional quality and trade as statistically significant predictors of Internet diffusion, reported spurious results? We believe not. Rather, the answer most likely lies in the fact that these four explanatory variables change relatively little during the short span of Internet diffusion, such that the country fixed-effects estimation becomes extremely inefficient. The country fixed-effects, together with the existing level of uptake, absorb an enormous amount of variation in the data over the twelve years of data covered in the study. Hence the country fixed-effects estimator most likely fails to identify the effect of the material determinants.

Conclusions

As Graham (1998: 171) observes, ‘promises of brave new worlds with universal, beneficial, totalizing shifts and secular technological Utopias’ run deep in modernist

⁴ We have no explanation for why the political constraints variable becomes significantly negative in case of mail. Yet institutional quality is a variable that changes very little over time. For such variables, it is not uncommon for the estimated coefficient sign to switch in moving from random- to country fixed-effects estimations.

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discourse. Indeed, they have emerged in popular representations of the Internet, fuelled by the hopes, expectations and futuristic imaginings of techno-optimists and techno-evangelists. Hence the Internet has often been portrayed as a uniquely disembodied medium, capable of collapsing physical distance, transcending geographic barriers and rendering less significant, or even obsolete, territorially-based geographic characteristics.

The reality, according to many geographers, is very different. The Internet's flows of data, information and services are not territorially disembodied. Rather, they are grounded in real places, where the wires, computers and users that comprise the Internet are located. What is more, far from the imaginary of ubiquity, the territorialisation of the Internet in place-based context is highly uneven. Thus, certain places are more connected than others, while others are completely detached from the digital spaces of the Internet altogether (Graham 2002; Rutherford 2005; Sassen 2002; Warf 1995, 2001).

For Malecki (2002), underlying these popular misunderstandings of the Internet is the newness of the technology, which 'has masked the fact that the Internet continues several long-standing characteristics of communication technologies' (399). One such characteristic is spatial inequality in access, availability and usage, which has been a hallmark of communication technologies, both old and new alike. Another potential, but barely researched, area of continuity lies in the determinants of these spatial inequalities (Graham 1998; Warf 2001). It is quite possible that the grounding of the Internet network in territory is subject to the very same material attributes that governed the uneven uptake of previous communication technologies.

In the present paper, we investigate this thesis. Taking the nation-state as our unit of analysis, we use econometric techniques to examine the material correlates of cross-

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national variations in the domestic uptake of mail, telegrams, telephone and the Internet. Our data begin in the 1870s and cover the major periods of growth in the global uptake of these four technologies. They therefore provide an extensive historical source to investigate the generalisable determinants of communications technology adoption and usage.

Our statistical results reveal a striking level of continuity in the territorial and relational attributes shaping the uptake of communication technologies over the past two centuries. We thus find income has not only influenced spatial variations in the growth of Internet users, but also mail, telegrams and telephone systems.⁵ The idea that income might act as a constraint to the adoption of the Internet in low income countries, of course, has underpinned debates about an emerging digital divide (Gibson 2003; James 2003; Perrons 2004). Our study suggests that there is nothing new in the importance of income. Historically, cross-national disparities in wealth have also produced inequalities in people's usage and/or access to communication services.

Historical continuity is also apparent in the case of education and international trade. Thus, levels of human capital – proxied in the present article by tertiary education – emerge as a positive statistical correlate of domestic growth rates for mail, telegrams, telephones and Internet users. These findings are revealing. Metaphors of the information society lend the impression that human capital occupies a uniquely important role in governing participation in the online worlds of the Internet. Yet our findings suggest that the importance of a well-educated population also applied to countries' uptake of previous generations of telecommunication technologies.

⁵ For mail the effect of GDP per capita is not statistically significant in random-effects estimation.

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Similarly, we find that trade openness is an important relational attribute shaping domestic uptake. A higher share of trade in GDP is found to be associated with a faster growth rate of all four communication technologies examined in the present study. Transnational networks via export and import linkages would, in other words, appear to act as a catalyst for the domestic expansion of communication services, both old and new. The importance of trade in diffusing new technologies, knowledge and competitive pressures is well-documented (Gertler 2001; Neumayer and Perkins 2003). What is striking in the present context, however, is its influence over four different communication technologies.

What are the wider implications of these findings? First, and perhaps most importantly, they caution against futuristic claims about the novelty of the Internet's geography. By enabling a further stretching of social relations, the Internet may indeed be contributing to a re-configuration of material geographies, both in the urban, economic and political sphere. Likewise, the Internet may be giving rise to new electronic spaces – the real, imaged or synthesised places of online activity. Yet our study suggests that the Internet has not rewritten long-standing rules of technological diffusion. It is not spreading according to some idealised and technologically determined trajectory (Zook et al. 2004). Nor is it less a fortune to country-bound material geographies than previous communication technologies. Rather, Internet usage would appear to be unfolding unevenly across geographic space according to long-standing territorial (i.e. income, education) and relational (i.e. trade) attributes.

Keohane and Nye (1998, 82) are therefore right in suggesting that the cyberworld of the Internet 'overlaps and rests on the traditional world.' Usage of the Internet is

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indeed fragmented along conventional contours of wealth, education and trade (Kichin 1998, 400), contours which have similarly shaped the uptake of mail services, telegrams and telephones. While the technology may be new, in other words, the material conditions which have shaped its uptake across geographic space are not. In terms of its own geographical diffusion dynamics across countries, the Internet revolution is anything but revolutionary (Goulding 2000, 171).

These findings are instructive for wider debates in geography about the ongoing importance of place. Specifically, they lend empirical weight to claims that place-based characteristics still matter (Agnew 2001; Bunnell 2002; Gorman 2002; Gorman and McIntee 2003; Kelly 1999; Rutherford 2005). That the uptake of the Internet depends on similar country-bound attributes which shaped past communication technologies strongly suggests that its space shrinking capacities have not diminished the significance of the material context (Venables 2002). Indeed, if anything, they would appear to have heightened them. To the extent that the Internet has become an increasingly important technology defining the fortunes of countries, factors such as income, education, institutional quality and trade have come to assume a decisive influence over development prospects (Gillespie and Robins 1989).

Of course, this does not mean that there is nothing that policy-makers can do to support uptake of the Internet. A rich case-study literature has documented many successful government interventions promoting Internet access, availability and usage (Guillén and Suárez 2001; James 2003). However, our study suggests that we cannot simply assume that the technology will by itself become instantly available to everyone, everywhere. Although opening-up new space shrinking possibilities, the Internet remains

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no less a product of the domestic economic, political and relational context than past communication technologies.

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Table I. Random-effects estimation results.

	Internet	mail	telegram	telephones
ln (Internet users p.c.) _{t-1}	-0.281 (11.63)***			
ln (mail items p.c.) _{t-1}		-0.010 (2.48)**		
ln (telegrams p.c.) _{t-1}			-0.065 (6.39)***	
ln (telephones p.c.) _{t-1}				-0.037 (8.28)***
ln GDP p.c.	0.324 (7.12)***	0.008 (1.15)	0.044 (3.19)***	0.066 (7.65)***
Tertiary enrolment ratio	0.002 (1.91)*			
Students p.c.		0.681 (1.72)*	4.779 (1.69)*	1.381 (3.11)***
Institutional quality	0.168 (2.19)**	0.004 (0.29)	-0.034 (1.39)	-0.008 (0.62)
Trade openness	0.137 (2.85)***	0.008 (2.13)**	0.010 (4.02)***	0.034 (3.51)***
Observations	923	2695	1750	3667
Countries	140	70	65	102

Notes: The dependent variable is the annual growth rate in technology uptake. Absolute z-values in parentheses. Constant and year-specific time dummies included, but not reported. * significant at .1 level ** at .05 level *** at .01 level.

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Table II. Regional fixed-effects estimation results.

	Internet	mail	telegram	telephones
ln (Internet users p.c.) _{t-1}	-0.282 (11.57)***			
ln (mail items p.c.) _{t-1}		-0.019 (3.57)***		
ln (telegrams p.c.) _{t-1}			-0.069 (6.84)***	
ln (telephones p.c.) _{t-1}				-0.036 (8.17)***
ln GDP p.c.	0.335 (6.62)***	0.029 (2.72)***	0.044 (2.32)**	0.056 (6.47)***
Tertiary enrolment ratio	0.002 (1.76)*			
Students p.c.		0.935 (2.04)**	4.923 (1.64)*	1.022 (2.30)**
Institutional quality	0.155 (1.97)**	-0.018 (1.16)	-0.036 (1.39)	-0.003 (0.19)
Trade openness	0.141 (2.67)***	0.007 (2.03)**	0.011 (4.25)***	0.032 (3.45)***
Observations	923	2695	1750	3667
Countries	140	70	65	102

Notes: The dependent variable is the annual growth rate in technology uptake. Absolute z-values in parentheses. Regional dummies and year-specific time dummies included, but not reported. * significant at .1 level ** at .05 level *** at .01 level.0

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Appendix. Country fixed-effects estimation results.

	Internet	mail	telegram	telephones
ln (Internet users p.c.) _{t-1}	-0.465 (14.12)***			
ln (mail items p.c.) _{t-1}		-0.083 (7.17)***		
ln (telegrams p.c.) _{t-1}			-0.090 (8.17)***	
ln (telephones p.c.) _{t-1}				-0.056 (8.55)***
ln GDP p.c.	0.206 (0.67)	0.108 (5.01)***	0.030 (0.81)	0.077 (5.30)***
Tertiary enrolment ratio	-0.003 (0.47)			
Students p.c.		1.205 (1.59)	7.224 (2.11)**	0.883 (1.55)
Institutional quality	-0.053 (0.29)	-0.049 (2.09)**	-0.026 (0.87)	-0.017 (1.11)
Trade openness	-0.218 (1.26)	0.009 (2.18)**	0.010 (3.77)***	0.045 (2.59)***
Observations	923	2695	1750	3667
Countries	140	70	65	102

Notes: The dependent variable is the annual growth rate in technology uptake. Absolute z-values in parentheses. Country dummies and year-specific time dummies included, but not reported. * significant at .1 level ** at .05 level *** at .01 level.