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ABSTRACT *In this paper we analyze how distances between a sample of a hundred major world cities varies when measured in cyberspace. The project develops a novel spatial statistical model based upon the number of user-generated placemarks indexed by Google Maps. We demonstrate how this metric captures the "invisible" patterns of intercity information flows and helps comprehend the contours of the complex digital network that exists between large urban centers across the world. Using a specially designed software program to interrogate Google Maps, a series of keyword searches ("tourism," "business," "hotel") as well as each of the city names were conducted in each of the sample places. Comparing this digital measure with the material movement of people and other relevant descriptive variables, such as national economic development and language differences, we were able to provide a cogent model that plausibly explains why certain city pairs (especially those that are physically distant) exhibit strong informational linkages. While the strength of these digital connections undoubtedly demonstrates the continued importance of physical proximity and established transport infrastructures in the twenty-first century, one can also observe significant evidence for [new?] digital "wormholes" which indicates that processes of globalization driven by online interaction also operates by its own rules.*

Distance and Human Geography

[N]ow we have the emergence of cyberspace.... It is largely invisible to conventional methods of observation and measurement.... We need to begin to map this space, to visualize its architecture, and to show how it connects to and transforms our traditional geographies. The task before us is urgent, baffling, and exciting.... Michael Batty (1993:616)

The role of physical distance in human geography has long been a topic of interest for researchers (e.g., Christaller, 1966; Gottmann, 1961; Gould, 1991; Janelle, 1969; 1973). The shrinking and warping of the world operates unevenly and with differential scalars effects (Harvey, 1989; Swyngedouw, 2001). The implication is that conceptually measuring *distances* between places has become *increasingly* complex: depending on a growing range of ways (some linear and fixed, others elastic and mutable) in which places are connected. While previously transportation and communication were necessarily combined—i.e., a *mobile* individual carrying a message on *physical* media—with the rise of telecommunication technologies beginning with the semaphore, telegraph, and telephone in the late eighteenth and through the nineteenth centuries (cf. Standage, 1998) this bond decoupled. Whereas physical mobility (transport via cars, trains, boats, aircraft,

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etc.) is still associated with time constraints and fixed places, it has become ever more possible to maintain synchronous and effective contact with people and businesses in *other geographical locations*: the development and widespread deployment of successful layers of information and communications technologies (ICTs) have facilitated a decoupling of simultaneity in time from the contiguity in space when mediated interaction in cyberspace (Castells, 1996).

However, it is important to note that this progressive decoupling in ICT use does not lead to a general "death of distance" or "flattening of the world" as posited by so-called post-industrial theorists. These commentators claimed that a "revolution" caused by information and communication technologies would completely transform economic and social relations across the world: physical distance is rendered largely irrelevant in decision-making, physical transportation and geographically-determined accessibility obsolete (cf. Cairncross, 1997; Friedman, 2006; Negroponte, 1995). Such post-industrial visions remain entirely unmet in several key respects (Graham, 1998): while improvements in telecommunications and computer capacities brought increasing connectivity at steadily decreasing real terms prices, reduced cost of communication did not eliminate the influence of distance and geography because of the political economy of provision. The Internet, for instance, an exemplar of open global communication, has real and specific constraints of infrastructure, user demand, governmental restrictions, market regulation, etc. that created a differentiated centrality (Kellerman, 2002). Certain places have more reliable telecommunications access, more available content, more economic activity and more Internet users than others (cf. Dodge and Kitchin, 2000; Warf, 2001; Zook, 2005). As such we need to recognize that geography and technology shape each other in complex ways. Although the transformative effects of ICT lead, in some respects, to the shrinking of scales and plasticity of space, they certainly do not lead to the "death of distance."

More generally, we argue that while spatial barriers are, to some extent, overcome by increases in the speed and in the lowering of real costs of transporting material goods, information, and people, on the other hand, some places remain relatively more remote from each other because of traffic congestion, poor rail links or no airport facilities, inadequate fiber-optic bandwidth capacity, or software firewalls and censorship (Graham and Marvin, 1996; Graham, 2008; Malecki, 2002). Thus, although large parts of the globe are now criss-crossed by a truly transnational network of high-bandwidth cables and almost entirely covered by high-speed air transportation networks, some places enjoy greater accessibility or are "more central" than others. Furthermore, many millions of people live in sight of an airport or with fiber-optic cables down the street, but can afford neither a plane ticket nor a laptop.

Measuring this centrality of the distance between places depends on accounting for the variability in how they are differentially inter-connected. The aim of this paper is to investigate elements of this multiple "elasticity." That is, we compare distances or intercity connectivity measures based on the observed *density of Web media* to distances based on airline passenger flows as well as simple physical proximity. Through this, we introduce a novel metric of distance based on the varying intensity of information produced about cities in popular online maps.

The structure is as follows: first, we review a range of spatial connectivity measures appropriate for city-scale analysis and argue why urban and regional scientists should also be interested in a new breed of *cyberspatial proximity* *metrics*. Second, we discuss relevant, albeit divergent measures of distance, and then define and justify our novel cyberspace metric of distance based on the way cities are bound together in reciprocal relationships in Google Maps' data representation. In the third section, we present an empirical analysis on the distance in cyberspace between one hundred major cities and compare those with the other two distance metrics. Finally, we evaluate our findings and conclude with suggested avenues for further research.

Uncovering Connectivity in the Global Urban Network

Measuring "distance" between cities has long been of interest to geographers and other scholars (e.g., Christaller, 1966; Gottmann, 1961; Gould, 1991; Janelle, 1969). In more recent decades, this interest has most prominently been manifested in the field of world city network (WCN) studies. For example, several analyses have been published on cities' connectivity based on infrastructure networks (e.g., Cattan, 2004; Townsend, 2001) or linkages across corporate organizations (e.g., Alderson and Beckfield, 2004; Beaverstock et al., 2000) in order to better comprehend the interactions or "distances" between cities in the globalized network economy. While these analyses are of major and continuing importance, their focus has been predominantly on material media or visible networks of interactions between major cities across the world, for example, based on couriers and postal mail traffic (Mitchelson and Wheeler, 1994), air passengers (Derudder et al., 2007), ocean going shipping containers (Verhetsel and Sel, 2009), or the indicative amounts of optical fiber between places (Malecki, 2002; Warf, 2007a,b; Warf and Vincent, 2007). With the growing dominance of communication technologies such as the World Wide Web and mobile telephony, the importance of measuring also the more virtually mediated element of global urban interaction has increased in significance.

In particular, the challenge is measuring the growing but decentered patterns of production and consumption of intercity *information* flows in the twenty-first century. Fortunately, the information and communication technologies at the heart of these patterns provide some useful technical mechanisms to measure and visualize the otherwise opaque patterns of intercity information relative to physical space. Precisely because these systems must codify the links between people and places—e.g., unless an Internet URL is properly specified it will not function—they can make information traceable as it is transmitted between two points or people, at least in theory; in practice it is often more tricky (cf. Dodge and Zook, 2009). In other words, whereas previously, data about invisible "informational" connections (e.g., financial flows, cultural links, exchanges of ideas, images, signs, patents, scholarly citations, media references, etc.) between cities were difficult to obtain (except from information flows based on surrogate measures as air passenger traffic or corporate organization networks), the media of the Internet enable us to measure this world city network (WCN) connectivity in significantly more detail. Moreover the methods are also low-cost, relatively quick and do not require any special access besides a connection to the network. This means that researchers are less reliant on government statistics or expensive commercially generated marketing data.

A number of researchers have used the opportunities offered by the Web as a rich representational media for analyzing the global urban system as a "represented" transnational network of ideas, images, and information (e.g., Barnett et al., 2001; Barnett and Park, 2005; Brunn, 2003; Devriendt et al., 2008, 2010; Zook, 2005; Zook and Graham, 2007). Park and Thelwall (2003), for example, promote this distance measure in the belief that with the increasing importance of the Web for an ever-broader spectrum of human activities, the structure of the Internet will reflect more and more the existing relationships between people, cities, institutions, and so forth. Others, like Heimeriks and Van den Besselaar (2006), analyze hyperlink networks on the scientific Web in order to study the development of academic fields and the relationship between research organizations and the relevant institutions in their environments.

In this body of work, particularly innovative approaches have exploited the advent of web-based services that integrate online information with geographic location in free and easy-to-use interfaces (some of the most visible include Google Maps, BingMaps, Yahoo!Maps, OpenStreetMap, and GoogleEarth). Drawing upon existing directories of individuals, facilities, and businesses, these services allow people to conduct *spatially* referenced searches of *online* material (including helping solve mundane but socially significant daily activities like "how many banks are located near this address?" "Where is the nearest pharmacy that is open on a Sunday?").[1] By facilitating these types of individually defined spatial searches, the complex inter-weaving connections between the virtual and physical worlds—long existing but largely opaque—are made more visible. While one can view these services as simply useful enhancements to pre-existing information repositories, such as mapping phonebooks and yellow pages listings, this paper argues that elements of this activity are actually interconnecting the material and informational world in fundamentally new ways.

One key element of the sorting function is the way in which it determines how listings are ranked. This builds upon studies of the interaction of software and space such as Thrift and French's (2002) idea of "the automatic production of space" and Dodge and Kitchin's (2005) analysis of how code "tranduces space." These approaches recognize software as increasingly relevant to how space and places are used. In the case of Google Maps, a software algorithm combines physical distance with a measure of online reputational worth; consequently listings which are farther away physically may be ranked higher. This is because entities with well established presences in cyberspace are presumed by the ranking algorithms to be more relevant than others to solve most searchers' needs (and, one might argue, also to serve). This sorting by online algorithms create what Zook and Graham (2007) term "DigiPlace," a process in which some content becomes more visible and other objects are pushed to the periphery. This makes online visibility relevant to a whole new range of activities ranging from taxi services to dry cleaning to neighborhood activism. If one is not on the network, then one is simply shut out of the means by which an increasing part of the world seeks to find services and know themselves (Castells, 1996, 2008). Such algorithmic sorting, when applied to social activities and places, can also have political consequence in terms of equity of information and scope for discrimination (cf. Graham, 2005).

Arguably even more significant in terms of social implication, is the opportunity offered by online spatial search services like Google Maps for individuals to author their own geographically referenced data. For example, users can record comments such as, "This is the best pizza restaurant," that are then stored and shared as so-called user-generated resources. These can be considered radically new "cyberscapes"—socially constructed informatic landscapes blending together the materiality of place with multiple digital representations of place—which can be used to understand contemporary mediated places around the world and the connection between them (Crutcher and Zook, 2009).

To illustrate our notion of "cyberscapes," Figure 1 presents a visualization of the aggregate number of user-generated placemarks within the city of New Orleans stored within the Google Maps database (see Graham and Zook, 2011 for an overview of the process by which this map was generated). This highlights the highly uneven geography of user geo-coded annotations which increasingly exist as digital overlays to cities. This information layer can be accessed remotely or *in situ* and shows which parts of an urban area generate the most interest within

(a)

Figure 1. User-generated cyberscapes of New Orleans, USA
Source: Aggregation of the number of placemarks containing the keyword "1" (upper image) or "mardi gras" (lower image). Larger circles indicate more placemarks and the legend scale ranges from 0 to 21,118 (upper image) and 0 to 652 (lower image). Data collected by authors' survey of Google Maps in February 2009 using a 100-meter grid of the New Orleans metropolitan area comprising approximately 75,000 unique points. Data is visualized in Google Earth from which these screenshots were taken.

active geo-coding users. The top figure is a general measure of *placemark density* while the lower one is limited to placemarks that contain the term "Mardi Gras." The first cyberscape shows concentrations of placemarks that correlate well to the density of economic activity of the city (the downtown business and tourist districts are delineated remarkably well); the latter is much more nuanced. Not only is there a large concentration of placemarks in the historic French quarter (the site of the largest Mardi Gras celebration) but clusters around the location of the storage facility for Mardi Gras floats as well as the sites of numerous smaller and less touristic, neighborhood celebrations.

By analyzing user-generated placemarks, researchers are afforded a glimpse of how individuals (as opposed to corporate or other institutional actors) author meaning about particular places. To be sure, the collections of individuals engaged in this voluntary annotation of maps almost certainly do not represent a random cross-section of the population: if nothing else, they are by definition more motivated to create online annotations. Nevertheless, user generated cyberscapes are allowing more voices into the discussion about the meaning of places. The opportunity and challenge offered by the increasing availability of geo-referenced data and participatory services in cyberspace (Zook and Graham, 2007) is to explore how this user generated representation—"Internet is as real as life itself" (Castells, 2000:23) —can inform us about the world.

Informational Distance Based on User-Generated Placemark References

The cyberspatial measure of intercity connections developed by the authors is based upon the number of placemarks indexed by Google Maps at the city center of 100 global metropolitan areas (as located by ESRI data) with the largest flows of airline passengers originating from and traveling to them based on 2001 MIDT (Marketing Information Data Transfer) data.[2] The criteria of airline passengers (explained in greater detail later in the paper) is used because it acts as an indicator of potential *information* exchange (embedded in the mobile humans comprising the flow) between city pairs. The resulting city database has a strong U.S.-Canadian (39 cities) and European (27 cities) skew as one would expect given the nature of the global airline system (c.f., Zook and Brunn, 2006). However, cities from all world regions are included in the database (Asia = 13 cities, Latin America = 9 cities, Middle East = 6 cities, Australia/New Zealand = 4 cities, Africa = 2 cities) which provides a robust sample for the purposes of this paper.

Using a custom-designed software program written by the authors, a series of keyword searches on user-generated placemarks (as opposed to regular Google Maps directory listings) were conducted in each of the study cities and the number of hits were recorded. Queries were conducted on each of 100 city names in the database (e.g., "New York," "Taipei," "Dubai") to obtain a measure of digital connection between city pairs. In addition, searches in each city were done on a range of keywords such as "business" and "hotel" that have achieved a popularity of use in other languages; albeit via strong associations with the process of neo-liberal globalization. Clearly, any number of alternative keywords can be used but given the exploratory nature of this project, we sought to establish the broad contours of differences between places before moving onto more nuanced analyses.

In order to compare the relative number of placemarks in each city the keyword "1" was also queried. While it would have been preferable to use the total number of placemarks in each location, at the time of the search Google Maps queries required a character search term to be entered for it to return an answer. Nevertheless, results for spatial queries on "1" provide a robust measure of the total number of placemarks. Unlike other possible search terms (such as "e" or "pizza," "subway," or "church") which have a greater potential to be biased by language or cultural differences, the number 1 has a more uniform use worldwide. Spatial searches conducted on the Google Maps database were located at the center of each city, done for a radius of 5 miles and were limited to user-generated placemarks undertaken over one week in September 2009.

As an illustrative example of the process, Figure 2 displays the result of a Google Maps search for *user generated placemarks* containing the keyword "London" within 5 miles of the city center of Brussels.[3] In other words, these are geo-coded annotations (containing text, photos, or other digital material) that ordinary users created (e.g., this is my favorite chocolate shop in Brussels) using the mapping tools provided for free by Google. The number of placemarks identified in this query, i.e., the number of hits, was 104. The results of Figure 2 also provide some of the diversity of content of the 104 placemarks resulting from this query, i.e., a reference to a major London landmark (the Buckingham Palace) and documentation of someone's personal trip between London and Brussels. It is important to note, however, that not all placemarks have such a readily identifiable connection between city pairs. After all, Google Maps does not require that user-generated spatial annotations confirm to strict parameters or be limited to certain topics.

Nevertheless comparing the results of spatial queries in Brussels to other keywords (such as hotel, Riyadh, or Shanghai) or the same "London" keyword in our

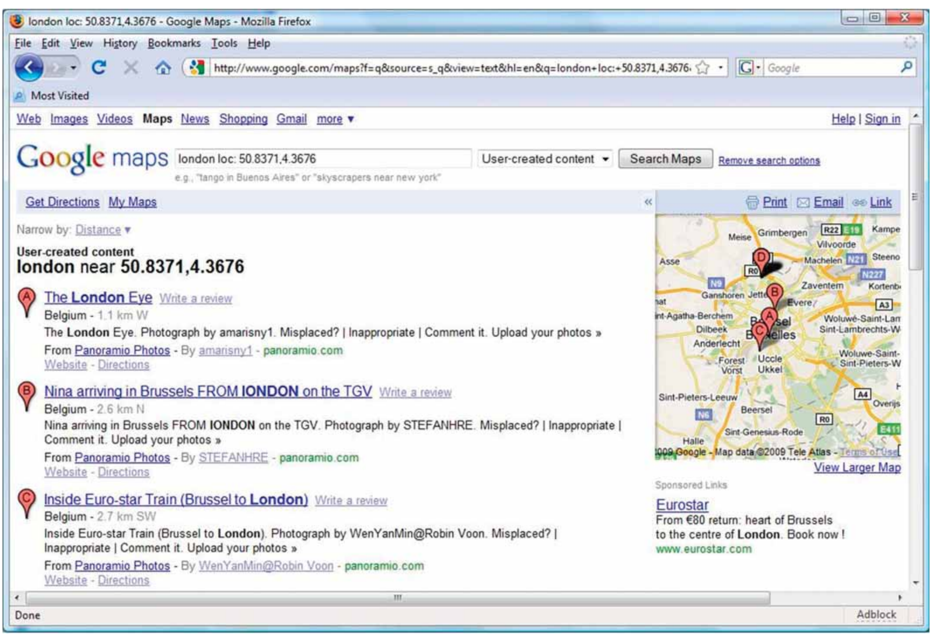

Figure 2. Screenshot of Google Maps search for "London" in user-generated placemarks in Brussels
Source: Author's screenshot from November 18, 2009.

other sample cities highlights distinct patterns that we believe give significant indictors of degrees of *digital connectivity* across the world-city network. For example, one would expect that cities that are "close" to London would have a higher number of user-generated placemarks than those that are "distant." However, as this paper works with three very different types of distance—physical, passenger flows, and informational—one expects that physically proximate cities to London (such as Manchester or Paris) and those that are strongly connected via airline or informational flows (such as Johannesburg, Sydney, or Los Angeles) would all have relatively larger number of user-generated placemarks than other cities.

Methodological Issues Regarding User-Generated Placemark Metrics

Given the novel nature of our proposed distance metric based on user-generated placemarks, it is prudent to address various methodological issues associated with the underlying data. First, it is clear that there is considerable difference between the amount of online information about places, and this includes Google Maps directory listings (Graham and Zook, 2011). While this is most apparent across the developed/developing world divide, there are also clear differences between North America, Europe, and parts of Asia. These discrepancies between cities, however, are lessened because this metric relies upon user-generated placemarks rather than commercially produced materials. Precisely because only user-generated content is included in the searches, other information resources are not relevant. It is clear that some cities have a higher absolute number of placemarks due to population size/densities, greater levels of affluence, and wider technological adoption levels, but when raw counts are standardized (including relative to the number of placemarks containing the keyword "1") these contextual differences are minimized.

A second issue is that all city names queried are in English rather than the local language of each city. This is problematic for cities with multiple language groups, for example, Montreal or Brussels, or where spelling varies considerable according to language, such as Helsinki or Geneva, or in which the local language uses non-Roman characters, like Tokyo or Athens. Despite these shortcomings our analysis consciously limits it searches to English spellings of city names because we sought the highest degree of consistency across the dataset (similar comprises in data querying evident in published work of Brunn, 2003; Brunn and Dodg,e 2001; Boulton et al., 2010; Devriendt et al., 2008). If multiple variations on city names were used (such as separate searches for Geneva, Genf, Genève, Ginevra, and Genevra in each of the other sample cities) the problem of how to combine potentially overlapping results arises. Should the results be added together regardless of duplicates? Should some kind of averaging be undertaken? More fundamentally, it removes the uniformity of the searches and raises questions as to whether it is appropriate to compare the results from a search on one keyword to the results of searches on multiple keywords.

Also influencing this approach is that despite increasing amounts of non-English online content, it remains the largest language group on the Internet (Berendt and Kralisch, 2009; Devriendt et al., 2011; InternetWorldStats, 2010), along with its acknowledged role as a *lingua franca* of the global media and international business more generally.[4] This is particularly the case for the type of inter-city informational connections that this project seeks to identify. Nevertheless, the make-up of keyword queries was done carefully to select words such as "bank" or "hotel" that have been widely adopted worldwide as generic terms (McCrum, 2010). However, we acknowledge that the influence of language cannot be completely mitigated and, consequently, the interpretation of the project's findings should keep this in mind as one of the inevitable, confounding factors that adds "noise" to this kind of analysis.

Lastly, perhaps the most fundamental methodological issue with this metric revolves around its interpretation: what is the significance of having a city name or other keyword contained within a user-generated placemark? Given the open nature of placemark creation, it is clear that the motivation and purpose of each placemark varies as much as the individuals creating them. The act of anchoring a placemark containing a specific keyword such as "tourism" or city name such as "Berlin," however, suggests some kind of tie between the location in which it is placed and the activity or city that it references (cf. Mummidi and Krum, 2008). This could be an overt reference, for example: "This street reminds me of the Ku'damm in Berlin," or by leveraging a famous name, such as, "The Berlin Bakery makes great bread" or simply an awareness of connections to other place, like, "This is where I lived before I moved to Berlin." In short, this metric offers an innovative way to examine the global information linkages emerging within the *cyberscapes of everyday life* and has significant potential to increase scholarly understanding of the structure of inter-urban networks.

To better illustrate the promise of this technique, we present the results from a search for a specific "international" keyword (a term that has achieved a popularity of use in other languages) in the different cities.[5] Figure 3 maps the number of the user-generated placemarks referencing the keyword "hotel" standardized by dividing by the number with the keyword "1" in each of the major cities in the database. The global spatial distribution of placemarks suggests a strong relation to major destinations around the world that are primarily tourism based (such as Venice, Cancun, or Las Vegas), international business oriented (Dubai, New York, and Shanghai), or related to religious travel (e.g., Jeddah). This supports our

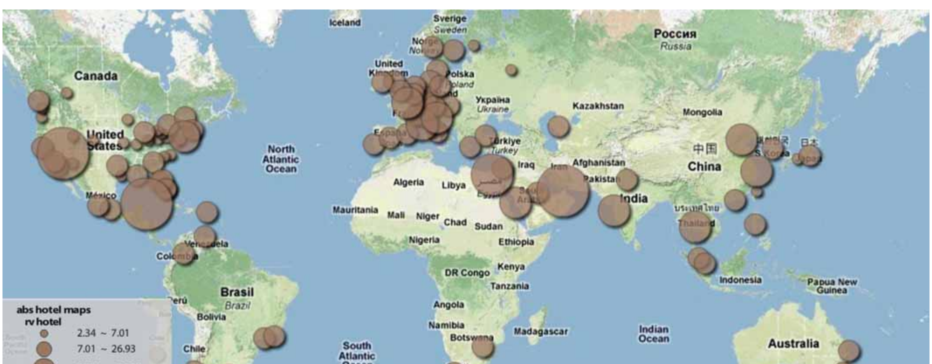

Figure 3. The relative number of user-generated placemarks on "Hotel"
Source: Author's screenshot of User-Generated Google Maps data using FortiusOne GeoCommons Software

argument that a metric based on user-generated placemarks—and in general using the increasing availability of spatial data and services in cyberspace—are potentially significant new tools in studying the structure of the global city network.

It is useful to compare this placemark metric to other more traditional ways of measuring association between cities. Given that the meanings of near and far have become more mutable with the uneven, multi-scalar shrinking and warping of the world, simple physical distance is clearly not enough in analyzing the interconnections of world cities. Neighborhoods (or even buildings) that are physically proximate may have little connection with one another while being tightly integrated with locations on the other side of the globe. A better comparison is based on airline passenger flows which represents the physical movement of information and knowledge (embodied in human beings). However, the wide variety (and short-comings) of data on air passenger flows requires careful selection of the most appropriate source for this kind of information.

Distance Metrics Based on Airline Passenger Statistics

Several different sources of airline statistics are available to analyze inter-city flows, including statistics reported by international agencies (such as ICAO, DB1B)[6] and commercial databases (like the AEA, OAG, SRS)[7] making the selection of the most appropriate and robust metric for analysis a complex decision. In the context of World City Network (WCN) research the most useful information is about the actually-flown routes of air travelers (and not the underlying logical structure of airline networks). For this reasons, our analysis uses MIDT data based on passengers' bookings based on information recorded in Computer Reservation Systems (a handful of such CRSs are used by virtually all travel agents across the world) that include reliable details about the origins, stopovers, and destinations of all air travelers from January to September 2001 (see Devriendt et al., 2009 for background detail on the nature and quality of the MIDT data). Due to the prohibitively high cost of this commercial database (millions of dollars), it was not possible to obtain a more recent version for this project. While the data are older than would be ideal, it is preferable to the alternatives as it clearly excludes passengers who are simply connecting in a city (which over-emphasize airline hubbing strategies at select airports) and instead reflects genuine travel between city pairs (Derudder et al., 2007).[8] For example, because of its role as a major hub for the U.S. carrier Delta Airlines, Cincinnati is among the world's fifty busiest airports in terms of flights, but is not ranked nearly as high in terms of passengers originating from or traveling to it. Since the focus of this research is understanding the informational connections between cities, data on the structure of the network by which people travel between cities are of much less relevance than the amount of travel between city pairs. Consequently, Cincinnati's role as a hub rather than as an origin/destination in airline travel means it is not included in our modeling.

Distance and Connectivity in the Global Informational Network

We present an analysis of the correlations between intercity connections as measured by geographical distance, airline passenger flows, and the new metric of prevalence of user-generated placemarks. While relationships between these metrics exist, they are neither straightforward nor necessarily linear; this is unsurprising given the multi-scalar shape of the contemporary world. We seek to explain the placemark measure of intercity connectivity via a formal modeling process. The goal of this is to test theoretical arguments as to why cities have strong informational linkages and identify generalizable factors that seem plausible at the global level. The findings of this modeling are then further tested by an analysis of the strongest intercity linkages to identify when and where the global factors succeed, or equally important, fall short in explaining observed connections. The analysis then proceeds to the city level to examine the potential of the user-generated placemark metric in a set of exemplar city case studies.

Placemarks, Passengers, and Distance

The hundred cities in our database exhibit a network of 4,950 intercity connections based on observations in this analysis. Figure 4 illustrates the relationship between the number of placemark connections (log), airline passengers (log), and distance. While the distance decay relationship between geographic distance and air travel patterns is well established (cf. Haynes and Fotheringham, 1984) our data confirm this trend as well as highlight how the functional links between cities can complicate this relationship. For example, the outlier points in the upper right of Figure 4A are the city pairs of London-Sydney and London-Aukland, illustrating how historical and economic ties between these places result in more passenger traffic than would be expected given the physical distance between them. Conversely, the outliers at the bottom right, the city pairs of Brisbane-San Juan and Kuala Lumpur-San Juan, provide the counter example. Moreover, it is enlightening to observe that a similar relationship holds between our new user-generated placemark metric and geographic distance. The strength of this association to distance is weaker than in the case of airline passengers (a correlation of -0.39 compared to -0.59), but it is visually evident and statistically significant. Also important is that the correlation between placemarks connections and air travelers is both positive and strong (a statistically significant correlation of 0.684). This suggests a high degree of similarity between the *physical* movement of information (embodied in mobile people) and the *virtual* flows of information (represented by user-generated placemarks). However, it is also evident that the variation within the correlations against placemark data occur upon more dimensions than physical distance alone, suggesting other factors are at work. For example, the outliers at the top of Figure 4A are for the city pairs of Fort Lauderdale-Miami and Portland-Vancouver in which combinations of proximity and airline networks result in significantly fewer airline passenger connections.

To explore these relationships further, our analysis developed a multivariable linear regression model to see what plausible factors are tied to the formation of intercity placemark connectivity. The unit of observation are intercity links and the model uses the total number of user-generated placemarks in city *A* referencing city *B* and the total number of placemarks in city *B* referencing city *A* as the dependent variable. As standard linear regression presupposes homoskedasticity (variables remains constant over the entire data range) it was necessary to use the logged values of placemarks (See Figure 4B) in this modeling. The untransformed data are highly variable and dramatically decrease as distance increases, which implies that residuals cannot be interpreted reliably.

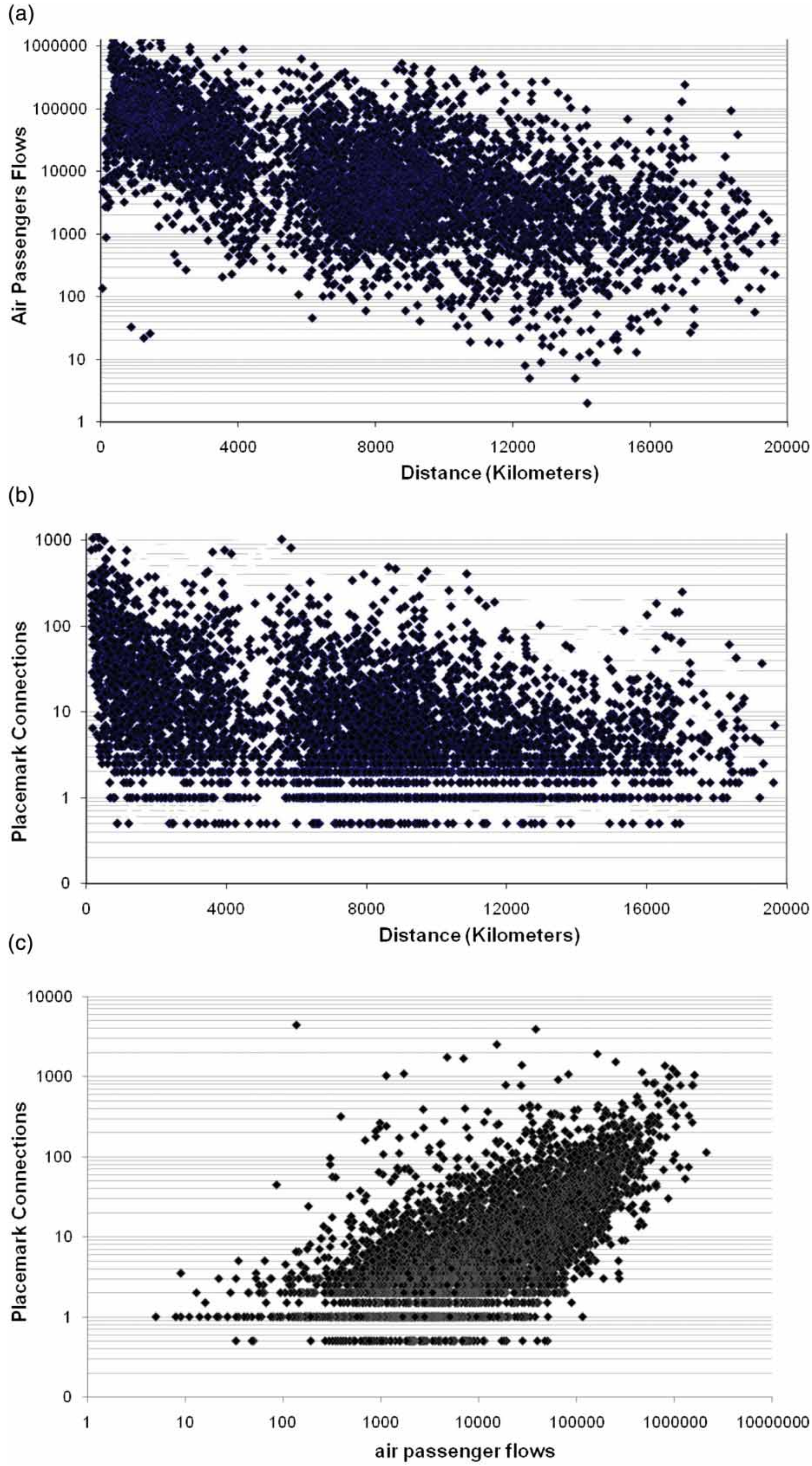

Figure 4. Scatterplots of correlations

The first independent variable used to account for the observed pattern of placemark connectivity between each city pair is the number of airline passengers traveling between the cities. This represents the material movement of people and captures both travel distance and varying population volumes. Due to the need for homoskedasticity the logged value of this variable is used as well. The next predictor is a total count of user-generated placemarks in both cities to control for differences in metropolitan cyberscapes around the world. Some cities (such as New York or London) have been extensively annotated by users, while others like Manila or Riyadh have many fewer and the effect of this on the search results needs to be controlled. Due to the structure of a Google Maps search (one must specify a keyword rather than use a wildcard or blank), however, it is not possible to obtain the total number of user-generated placemarks in a city. Instead we construct a metric of *"global" placemarks* in each city based on the number of placemarks for the keywords "bank," "business," "finance," "global," "hotel," and "tourism."[9] This provides a measure of placemark use within the city and given the variability of this measure, it was necessary to model the logged value. The third variable is the mean 2007 GDP per capita income (as recorded by the World Bank) of the countries in which the two cities are located. Although it would be preferable to use city-level rather than national-level income, these data are not available for all cities. Based on typical technology adoption patterns, it is plausible that more affluent places will generate more user-generated placemarks than poorer ones (cf. Graham, 2009).

The fourth variable is an ordinal control variable to compensate for a known bias in the database resulting from limiting search terms to English. User-generated placemarks in languages with alphabets that conform to or are closely related to the Roman alphabet (English, French, Spanish, German, etc.) are more likely than languages with non-Roman characters (Arabic, Korean, Japanese, Chinese, Russian) to be captured by the software used in this research. Using a simple typology, the model assigns each intercity link a weighting from 0 to 2: 0 if neither city in the pair uses a Roman-related language (e.g., Jeddah and Tokyo); 1 if one city uses a Roman-related language (Paris and Beijing); and 2 if both cities use a Roman-related language (San Francisco and Frankfurt). This straightforward approach provides an important measure of control to the modeling.

The next variables also address the linguistic impact of information exchange. Cities that share a language will likely engage in more interaction than those that do not have this commonality. In many cases, these linguistic ties are associated with historical (sometimes colonial) relationships, but these variables do not differentiate between the two. Using a series of six dummy variables (for Arabic, Chinese, French, German, Portuguese, and Spanish), city pairs are assigned a value of 1 if both cities share the same language or a value of 0 if they do not. If these language ties are relevant, then the dummy variables for (the six languages besides English that are used in more than one of the 100 cities in the database) will each add a unique value to the model's equation.

The sixth variable in the model builds upon the historical ties suggested by shared languages. The exclusion of English from the language groups was deliberate, both because the ubiquity of English renders it a poor linguistic variable, but more importantly because the model instead considers the historical ties of the British Empire. One plausibly expects that the strong ties built during the colonial period in terms of economics or culture has often prevailed into the flows of user-generated placemarks. This dummy variable refers to intercity linkages between

U.K. cities and places located in former British colonies. For example, the link between London and Hong Kong or Manchester and Sydney receives a 1, but the link between Hong Kong and Sydney, London and Manchester or New York and Los Angeles is given a 0.

The results of the models explain more than half of the variation in the metric of placemark connections between cities.[10] (See Figure 5.) As expected, the relationship of airline passengers to the user-generated placemark metric is strongly positive and statistically significant. City pairs with large numbers of embodied information exchange, i.e., travelers, also exhibit strong virtual information flows in terms of user-generated placemarks. A plausible case can be made that the physical movement of people is closely related to the exchange of ideas, but the causality is unclear (are user-generated placemarks references to other places driven more by personal travel experience or vice versa?) and in any case is most likely reciprocal. This is further confounded by interactions between places via media (e.g., the Americanization of world cinema given the cultural power of Hollywood) rather than direct experience.

As expected, the size of a metropolitan area's cyberscape proved to be highly significant. Cities that are well annotated with user-generated placemarks will plainly have more references to other cities as a matter of size. Likewise, the average income level of cities, according to national-level GDP, influences the extent to which placemark interaction occurs, so wealthier places are more likely to have a greater density of user-generated placemarks. This corresponds to historical experience with the adoption of earlier rounds of information technologies. The ordinal variable controlling for language character sets also performs as

Dependent Variable: Placemarks (log)

Num. of Obs.	4948		
F	557.505		
Adj. R^2	**0.553**		
Variable	**Coef. (ß)**	***t***	
Airline passengers (log)	0.34	40.44	***
Global placemarks (log)	0.87	31.85	***
GDP per capita	1.2E-06	8.84	***
Roman Alphabet	0.20	6.45	***
Arabic	0.50	0.86	
Chinese	2.44	5.87	***
French	1.08	3.03	***
German	1.45	7.31	***
Portuguese	2.27	3.89	***
Spanish	1.46	8.53	***
British Empire	0.35	1.94	**
Constant	-8.44		

* 90 % significance
** 95 % significance
*** 99 % significance

Figure 5. Model results

expected in modeling, such that cities whose language corresponds closely to Roman characters score higher in the placemark metric than place with non-Roman languages, and thus provides an important check on the how the dataset is representing "reality."[11]

It is, however, in the final two types of variables that some of the most interesting results are evident. As hypothesized, one can observe noticeable clustering of user-generated placemark connectivity among specificities in shared language groups. These configurations, however, exhibit varying degrees of strength depending upon the language. For example, neither Arabic nor French reach the necessary statistical threshold to be considered significant in our modeling. In contrast, city pairs which share the common languages of Chinese, Spanish, German, or Portuguese were found to have more user-generated placemark connections between them than would otherwise be predicted based on the other independent variables. Additionally, the final variable which identifies city pairs that represent inter-urban relationships built within the British Empire period is also positive and statistically significant. This finding supports the contention that the historical legacy of colonial relations can continue to influence contemporary patterns in which virtual information can be shared globally.

Although the model results conform well to expectations on which factors contribute to information exchange, much of the variation within user-generated placemark connectivity remains unexplained. The scatterplots in Figure 4 illustrate the degree to which placemark connections can differ strongly for city pairs with similar distance and airline passenger flows. While the model has sought to control for some of these differences, it is only through a closer examination of the specific nature of these links that these findings can begin to be untangled.

Analysis at the City-Connection Scale

To explore these relationships further, the next step in our analysis is to identify when and where the distance and connectivity in the global informational network differs from other distances such as airline passenger flows. Of particular interest is identifying the city pairs in which our new user-generated placemark method succeeds or falls short in explaining intercity distance since much of the variation is case specific. For example, the relatively close *cyberspace distance* recorded between Houston and New York is potentially distorted by the high number of placemarks related to Houston Street—the major east-west thoroughfare in downtown Manhattan. As this paper is a preliminary investigation into this new user-generated placemark measure, we are not able to examine all intercity relationships and instead focus on some outstanding cases. Table 1 presents the relationships (Pearson correlation) between the intercity airline linkages and the normalized intercity cyberspace connectivity for the twenty most important cities in terms of air traveler volumes (MIDT). Picking out further three different cases, i.e., Atlanta (Pearson's $r = 0.72$), London (0.50), and Miami (0.52), leads to some important insights in the shortcomings or the success of this new distance metric. (See Figure 6.)

Table 1 suggests that our placemark metric is not (solely) related to intercity airline volumes. However, when looking in detail at these cases, one can clearly observe that these relatively low correlation coefficients (the mean is 0.53) are

Table 1: Pearson r's for 20 most important cities according MIDT

RANK (MIDT)	CITY	PEARSON R
1	New York	0.45
2	London	0.50
3	Los Angeles	0.44
4	Paris	0.43
5	Chicago	0.65
6	Hong Kong	0.46
7	San Francisco	0.43
8	Frankfurt	0.50
9	Atlanta	0.72
10	Orlando	0.29
11	Washington DC	0.47
12	Miami	0.52
13	Boston	0.55
14	Toronto	0.71
15	Las Vegas	0.59
16	Bangkok	0.70
17	Dallas	0.47
18	Amsterdam	0.41
19	Singapore	0.72
20	Rome	0.72

case-by-case based on a small number of outliers caused by factors outside the airline field. Figure 6 presents, for instance, the intercity linkages in cyberspace and airline passengers for Atlanta, London, and Miami. Focusing on the Atlanta case (Figure 6a), we see that for both metrics Atlanta's most important intercity relationships are New York, Chicago, Orlando, Dallas, Miami, Washington, and Los Angeles. Atlanta's distance to other cities is largely consistent between cyberspace and airline passenger flows even though its role as a regional "hub city" in airline networks (see Derudder et al., 2007) could be expected to produce higher volumes of passengers.

While the consistency in intercity relationships for Atlanta is quite clear (with the exception of Buenos Aires, see discussion below), the cases of London and Miami exhibit a number of important outliers, i.e., Manchester and Paris for London and Orlando, Tampa, and San Juan for Miami. The remaining intercity connections for both cities are closely related to the flows of airline passengers: e.g., other cities such as Hong Kong, Amsterdam, Dublin, Frankfurt, Los Angeles, have similar levels of connection in both cyberspace and air travel. While many factors can influence the outliers, the cases of Miami and London highlight two particularly important issues behind variations in these distance metrics. Firstly, a short physical distance between two cities means significantly less travel by airline as alternative means (such as car or train) allow for travel in an equivalent amount of time. This close physical proximity also often results in a high level of cyberspace connectivity and helps explain why the cases of Manchester-London, Paris-London, and Orlando-Miami, Tampa-Miami are outliers. Secondly, because cyberspace distance is measured by the frequency of city name in user-generated placemarks, alternative and local uses of a city name will likely inflate the level of the cyberspatial connectivity metric. For example, the high number of occurrences of the term "San Juan" in Miami is distorted partially by references to a neighborhood known as "Little San Juan" in the city.

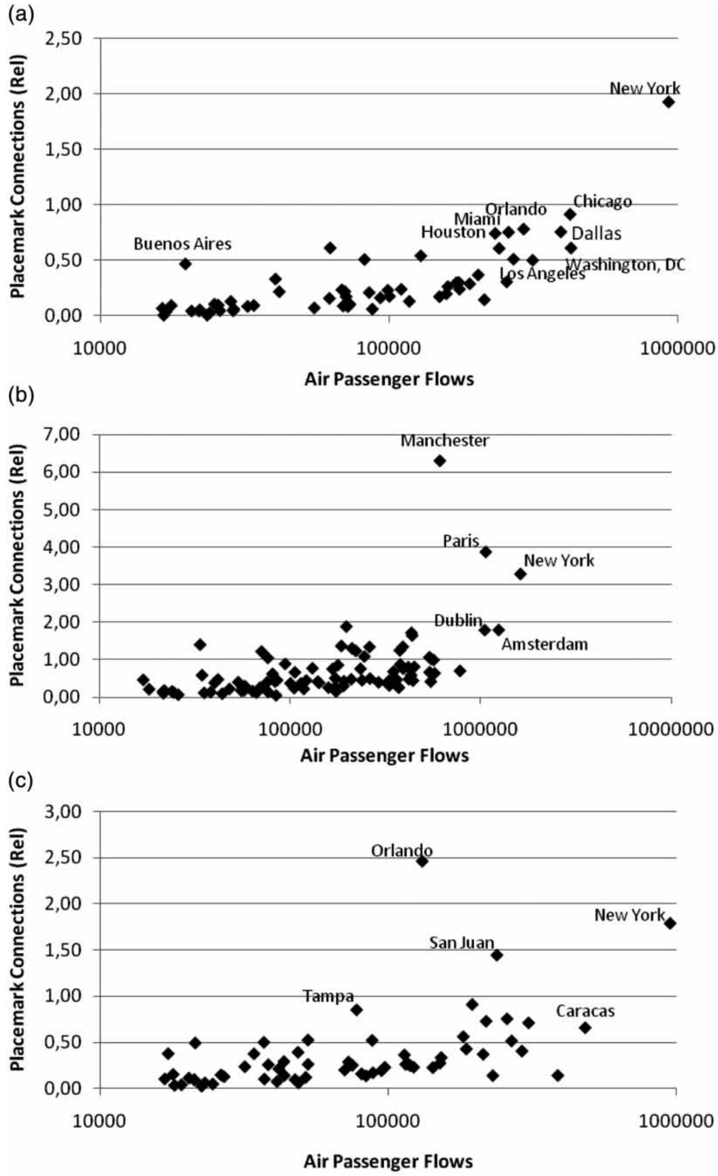

Figure 6. Relationships between intercity linkages in cyberspace and airline connectivity for Atlanta, London, and Miami (NB. Only intercity flows above 15,000 passengers are listed).

This latter factor suggests (like in other cases such as Houston, Hamburg, Charlotte, etc.) that our metric fails when city names are widely replicated via nearby locations, street names, or other non-geographical meanings.

Besides the above-mentioned "outliers" caused by language difficulties or a close physical distance, there are a number of outliers generated by other processes which suggests that digital globalization also operates by rules that differ from traditional media. It is precisely these city-pairs which exhibit a stronger than expected digital connectivity (or are in some senses closer to one another in cyberspace) given the amount of travel between them, that suggest new patterns of networks within the global city system. These could be thought of as *"wormhole" connections*, and they open up a tantalizing suggestion of possible interaction that is less dependent upon the movement of people. That said, it is entirely possible that these digital connections can generate the physical movement of people.

In order to find out the origin of these "wormholes," we conducted additional searches on Google Map's user-generated placemarks based on the two-side relationship between the cities, that is, we looked for the relationship of for instance Buenos Aires in Atlanta *and* Atlanta in Buenos Aires. This leads to interesting cases—perhaps revealing new and emerging trends—, these are the important cyberspatial connections between Milan and Buenos Aires, Paris and Riyadh, New Orleans and Paris, New York and Jeddah, Athens and Istanbul, Washington and Tokyo, Moscow and Athens, Tokyo and Los Angeles, and New York and Las Vegas, referring to cultural, historical, religious, and other (at present unknown) associations that go beyond traditional distance or travel. Research challenges arise from these new insights; that is, our novel cyberspatial approach exploiting user-generated placemarks offers a new take on the methodological question of how to understand the uneven shrinking or plasticity of space in the current age.

Conclusions

Following Batty's note (1993, see quote in part I), this paper visualizes and analyzes the increasing degree of inter-city connectivity that cyberspace is facilitating. Based on a comparison of a digital intercity metric based on user-generated placemarks with the material movement of people and other relevant variables (i.e., the digital, economic, and linguistic development of a city), we provided a first step in explaining how the growing dominance of informational linkages are enrolled in the (re)structuring of a globalizing urban society and in some ways is transforming established geographies. While the variation we measured in the strength of the digital intercity connections shows the continued importance of established patterns of exchange and relative accessibility—based on language, physical distance, transport infrastructure, uneven development, etc.—one also sees evidence for other processes that indicates that the globalized urban network cannot only be understand in a material linked world. The main conclusion is, therefore, that in the contemporary globalized information society, conceptualizing and measuring urban networks has become a complex undertaking depending on a mix of distance geographies.

In order to better comprehend one of these geographies, in this paper, we focused on the informational connections by user-generated placemarks. Our empirical analyses detail how highly accessible cities which have in general great power in most material urban networks (see e.g. Beaverstock et al., 2000; Zook and Brunn, 2006) also dominate the virtual urban information system in cyberspace. The most accessible cities in terms of physical mobility, such as London, Paris, Hong Kong, New York, Los Angeles, and other major cities have, in turn, a high-level of cyberspace connectivity. Similarly, less connected urban pairs, such as Houston-Johannesburg (3,267 passengers) or Munich-Baltimore (2,652 passengers), exhibit less attraction in the user-generated cyberspace (respectively 4 and 3 placemarks).

National/regional links, on the other hand, founded on a close geographic distance, are more highly ranked than could be expected from established material connectivities (e.g., air travel). Following Tobler's so-called First Law of Geography "everything is related but near things are more related than distant things" (Tobler, 1970), this creates smaller cyberspace distances in the informational connections between cities such as Paris and London, Brussels and Amsterdam, Beijing and Shanghai, New York and Boston, etc. Further, the number of user-generated placemarks about city *A* in city *B* does not only depend on the (ease of) information exchange by travelers, but also needs to be viewed in terms of cultural, social, national, economic, historical, and other related connectivities. We could observe, for instance, noticeable clustering within intercity placemark connectivity among specific language groups. City pairs which share in a specific group of languages were found to have significantly more user-generated placemark references between them than would otherwise be the case.

Another signifier of this variation is what we termed digital "wormholes"; these significant cyberspatial intercity connections feed a strong association between places that extend beyond established accessibility and bring people and places into virtual proximity. This demonstrates that understanding distance is not a purely Euclidean or material-based exercise, as any node in the digital network could be seen to be "close" to another node independent from absolute miles, but near if measured through the "wormhole" that provides countless messages, images, sounds, and other economic opportunities and social interactions (Graham, 2008). This means that while Tobler's first law remains valid, the notions of near and distant cannot be limited to physicality but include relational, cultural, temporal, and other dimensions. It is these latter factors that make further research based on our cyberspatial metric increasingly profitable.

In conclusion, we would emphasize that user-generated digital connections within the network of global cities need to be examined in much more detail because shortcomings as well as successes of the method influence the results. While we already understood from our results that methodological issues such as national-level GDP, language groups, distance, and the use of city names regarding user-generated placemark metrics are decisive, most of these are case-specific, and although we could see this as a limitation for our quantitative models, the attributional information that is linked to user-generated placemarks provides novel insights into city networks.

In general, we believe our analytical approach has utility in how it exploits relatively simple custom-designed software and publicly searchable online databases to provide innovative ways to measure distance and, thereby, an exciting window onto the spatiality of information production, circulation, and consumption and, as such, is of significant potential use to urban geographers and allied scholars (as well, of course, as commercial interests). In other words, the data and theoretical frameworks of this computer science-based research work await further study by geographers and others interested in the positions and experiences of (world) cities in the global information network.

Notes

1. Of course, the precision and reliability of the answers to these questions are limited to the data that are indexed and prioritized by these online databases.

2. The city of Nice, France (ranked 75th in terms of airline passengers) does not appear in the final database due to the alternative meaning of "nice" to convey something that is pleasant or agreeable. Due to this significant overlap of synonyms, Nice had more total placemark references (a total of 39,197) than any other city, e.g., the next three largest were New York (25,615), London (23,296), and Paris (22,887). Given this obvious discrepancy in ranking (having 50 percent more references than the global cities of New York, London, or Paris) and a clear understanding of what was causing it, the city of Nice was replaced by Moscow (ranked 101st in terms of airline passengers). While other cities also have synonym issues (e.g., Hamburg, Germany and Hamburgers; Charlotte, NC and a woman's name) they remain in the database. Although this increases issues of "noise" in the data, we prefer this approach over risks of arbitrarily "cherry-picking" the data.
3. The URL for this search is <http://maps.google.com/maps?f=q&view=text&hl=en&q=london+loc:+50.8371,4.3676&mrt=kmlkmz&radius=5>. The query can be tailored by adjusting various components such as replacing the text string "london" for another key word or the coordinate "50.8371,4.3676" (the city center of Brussels) for another location. However, because Google is constantly updating its index of data and tweaking its search algorithm, replicating this particular search will produce different results than shown in this figure.
4. A 2002 survey of 2,024 million web pages <http://www.netz-tipp.de/languages.html> determined that by far the most web content was in English (56.4 percent); next were pages in German (7.7 percent), French (5.6 percent), and Japanese (4.9 percent).
5. The blog <www.floatingsheep.org> provides a number of other examples of such searches at a number of different scales and topics.
6. ICAO (International Civil Aviation Organization), DB1B (Airline Origin and Destination Survey).
7. AEA (Association of European Airlines), OAG (Official Airline Guide), SRS (Schedule Reference Service).
8. An important nuance to the MIDT data is that cities in close proximity, e.g., Brussels and Paris, San Diego and Los Angeles, have well developed means of ground transportation (car, bus, train) between them. This means that the MIDT statistics tend to under-represent these connections between nearby cities. Fortunately, this is ameliorated in some cases by the inclusion within the MIDT database of origin/destination IATA codes that also encompass train and bus stations. For example, in addition to the air link between Brussels and Paris, Charles de Gaulle, Air France provides the Thalys High Speed train from Brussels South train station. Thus, a portion of ground travel is included in our modelling.
9. Note, other metrics using different generic keywords (such as "1") or combinations of keywords behaved identically to this variable in the models.
10. Sensitivity testing revealed no major changes in the final specification of the model. For example, the United States operates as an "early adopter" for many new technologies and can often skew any global modelling efforts. Moreover, the United States has the most cities of any country in the database (35 in total). However, removing the United States from the analysis does not change the model with a similar r-squared, and all variables are in the same direction and exhibit the same significance. Likewise, removing city pairs closer than 200 km (with alternative means of transportation) or outliers that are likely tied to data issues, e.g., the metropolitan area of Raleigh-Durham (spanning two separate cities) has 85 percent fewer placemark references than the next lowest city, Jeddah, produce no change in the direction and significance of the independent variables. In fact, the only effect was to increase the explanatory power of the model to an adjusted r-squared of 0.574.
11. Multi-collinearity between independent variables is always a concern within multivariate regression but the tolerance values reported by SPSS for these models, i.e., the percent of the variance of any one independent variable that cannot be explained by other independent variables, are all above 80 percent and in most cases above 97 percent, which means that our models are not unduly troubled by collinearity.

Bibliography

A. Alderson and J. Beckfield, "Power and Position in the World City System," *American Journal of Sociology* 109:4 (2004) 811–851.

J. Beaverstock, R. Smith, and P. Taylor, "World City Network: A New Metageography? *Annals of the Association of American Geographers* 90:1 (2000) 123–134.

G. Barnett, B. Chon, and D. Rosen, "The Structure of International Internet Flows in Cyberspace," *NETCOM (Network and Communication Studies)* 15:1–2 (2001) 61–80.

G. Barnett and H. Park, "The Structure of International Internet Hyperlinks and Bilateral Bandwidth," *Annals of Telecommunication* 60 (2005) 1115–1132.

M. Batty, "Editorial: The Geography of Cyberspace," *Environment and Planning B: Planning and Design* 20 (1993) 615–616.

B. Berendt and A. Kralisch, "A User-Centric Approach to Identifying Best Deployment Strategies for Language Tools: The Impact of Content and Access Language on Web User Behavior and Attitudes," *Information Retrieval* 12:3 (2009) 380–399.

A. Boulton, L. Devriendt, S. Brunn, B. Derudder, and F. Witlox, "World City Networks in Cyberspace and Time," in F.D. Firmino and C. Ultramari, eds., *ICTs for Mobile and Ubiquitous Urban Infrastructures: Surveillance, Locative Media and Global Networks* (Hershey, PA: IGI Global, 2010).

S. Brunn, "A Note on the Hyperlinks of Major Eurasian Cities," *Eurasian Geography and Economics* 44:4 (2003) 321–324.

S. Brunn and M. Dodge, "Mapping the 'Worlds' of the World-Wide Web: (Re)structuring Global Commerce through Hyperlinks," *American Behavioral Scientist* 44:10 (2001) 1717–1739.

F. Cairncross, *The Death of Distance: How the Communications Revolution Will Change Our Lives* Boston: Harvard Business School Press, 1997).

M. Castells, *The Rise of the Network Society* Oxford: Blackwell, 1996).

M. Castells, "Grassrooting the Space of Flows," in J. Wheeler, Y. Aoyama, and B. Warf, eds., *Cities in the Telecommunications Age: The Fracturing of Geographies* (New York: Routledge, 2000).

M. Castells, *Communication Power* (Oxford: Oxford University Press, 2008).

N. Cattan, "Le Monde au Prisme des Reseaux Aeriens" (The World through the Prism of Airline Networks)," *Flux* 58:1 (2004) 32–43.

W. Christaller, *Central Places in Southern Germany* (Englewood Cliffs, NJ: Prentice-Hall, 1966).

M. Crutcher and M. Zook, "Placemarks and Waterlines: Racialized Cyberscapes in Post-Katrina Google Earth," *Geoforum* 40:4 (2009) 523–534.

B Derudder, L. Devriendt, and F. Witlox, "Flying Where You Don't Want To Go: An Empirical Analysis of Hubs in the Global Airline Network," *Tijdschrift voor Economische en Sociale Geografie* 98:3 (2007) 307–324.

L. Devriendt, B. Derudder, and F. Witlox, "Cyberplace and Cyberspace: Two Approaches to Analyzing Digital Intercity Linkages," *Journal of Urban Technology* 15:2 (2008) 151–180.

L. Devriendt, G. Burghouwt, B. Derudder, J. De Wit, and F. Witlox, "Calculating Load Factors for the Transatlantic Airline Market Using Supply and Demand Data: A Research Note on the Identification of Gaps in the Available Airline Statistics," *Journal of Air Transport Management* 15:6 (2009) 337–343.

L. Devriendt, A. Boulton, S. Brunn, B. Derudder, and F. Witlox, "Searching the Web: The Position of Major Cities in the Information World," *Journal of Urban Technology* 18:1 (2011) 73–92.

M. Dodge and R. Kitchin, *Mapping Cyberspace* (London: Routledge, 2000).

M. Dodge and R. Kitchin, "Code and the Transduction of Space," *Annals of the Association of American Geographers*, 95:1 (2005) 162–180.

M. Dodge and M. Zook, "Internet-Based Measurement," in R. Kitchin and N. Thrift, eds., *International Encyclopedia of Human Geography* (Oxford: Elsevier, 2009).

T. Friedman, *The World is Flat: The Globalized World in the Twenty-First Century* (New York: Farrar, Straus & Giroux, 2006).

J. Gottmann, *Megalopolis: The Urbanized Northeastern Seaboard of the United States* (New York: Twentieth Century Fund, 1961).

P. Gould, "Dynamic Structures of Geographic Space," in S. Brunn and T. Leinbach, eds., *Collapsing Space and Time: Geographic Aspects of Communication and Information* (London: HarperCollins Academic, 1991).

M. Graham, "Warped Geographies of Development: The Internet and Theories of Economic Development," *Geography Compass* 2:3 (2008) 771–789.

M. Graham, "Wikipedia's Known Unknowns," *Guardian* Wednesday, December 2, 2009) <http://www.guardian.co.uk/technology/2009/dec/02/wikipedia-known-unknowns-geotagging-knowledge> Accessed March 25 2010.

M. Graham and M. Zook, "Visualizing the Global Cyberscape: Mapping User Generated Placemarks," *Journal of Urban Technology* 18:1 (2011) 115–132.

S. Graham, "The End of Geography or the Explosion of Place? Conceptualizing Space, Place and Information Technology," *Progress in Human Geography* 22:2 (1998) 165–185.

S. Graham, "Software-Sorted Geographies," *Progress in Human Geography* 29:5 (2005) 562–580.

S. Graham and S. Marvin, *Telecommunications and the City: Electronic Spaces, Urban Places* (London: Routledge, 1996).

D. Harvey, *The Condition of Postmodernity* (Oxford: Blackwell, 1989).

K. Haynes and A. Fotheringham, *Gravity and Spatial Interaction Models* (Los Angeles: Sage, 1984).

G. Heimeriks and P. Van den Besselaar, "Analyzing Hyperlinks Networks: The Meaning of Hyperlink Based Indicators of Knowledge Production," *International Journal of Scientometrics, Informetrics, and Bibliometrics* 10:1 (2006) 1–17.

InternetWorldStats, *Internet World Users by Language* (2010) <http://www.internetworldstats.com/stats7.htm> Accessed on January 20, 2010.

D. Janelle, "Spatial Reorganization: A Model and Concept," *Annals of the Association of American Geographers* 59 (1969) 348–364.

D. Janelle, "Measuring Human Extensibility in a Shrinking World," *Journal of Geography* 72:5 (1973) 8–15.

A. Kellerman, *The Internet on Earth: A Geography of Information* (London and New York: John Wiley, 2002).

E. Malecki, "The Economic Geography of the Internet's Infrastructure," *Economic Geography* 78:4 (2002) 399–424.

E. McCrum, *Globish: How the English Language Became the World's Language* (New York: WW Norton & Company, 2010).

R. Mitchelson and J. Wheeler, "The Flow of Information in a Global Economy: The Role of the American Urban System in 1990," *Annals of the Association of American Geographers* 84:1 (1994) 87–107.

L. Mummidi and J. Krumm, "Discovering Points of Interest from Users' Map Annotations," *GeoJournal* 72 (2008) 215–227.

N. Negroponte, *Being Digital* (London: Hodder and Stoughton, 1995).

H. Park and M. Thelwall, "Hyperlink Analysis of the World Wide Web: A Review," *Journal of Computer-Mediated Communication* 8 (2003) <http://jcmc.indiana.edu/vol8/issue4/park.html> Accessed February 20, 2010.

T. Standage, *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's Online Pioneers* (London: Weidenfeld & Nicolson, 1998).

E. Swyngedouw, "Neither Global nor Local: 'Glocalization' and the Politics of Scale," in B. Jessop, ed., *Regulation Theory and the Crisis of Capitalism* (Edward Elgar: Cheltenham, Glos, 2001).

N. Thrift and S. French, "The Automatic Production of Space," *Transactions of the Institute of British Geographers*," 27 (2002) 309–335.

W. Tobler, "A Computer Movie Simulating Urban Growth in the Detroit Region," *Economic Geography* 46:2 (1970) 234–240.

A. Townsend, "The Internet and the Rise of the New Network Cities, 1969–1999," *Environment and Planning B: Planning and Design* 28:1 (2001) 39–58.

A. Verhetsel and S. Sel, "World Maritime Cities: From Which Cities Do Container Shipping Companies Make Decisions? *Transport Policy* 16:5 (2009) 240–250.

B. Warf, "Segueways into Cyberspace: Multiple Geographies of the Digital Divide," *Environment and Planning B: Planning and Design* 28 (2001) 3–19.

B. Warf, "Geographies of the Tropical Internet: An Overview," *Singapore Journal of Tropical Geography* 28 (2007a) 220–238.

B. Warf, "Geopolitics of the Satellite Industry," *Tijdschrift voor Economische en Sociale Geografie* 98 (2007b) 385–397.

B. Warf and P. Vincent, "Multiple Geographies of the Arab Internet," *Area* 39 (2007) 83–96.

M. Zook, *The Geography of the Internet Industry* (Oxford: Blackwell, 2005).

M. Zook and S. Brunn, "From Podes to Antipodes: New Dimensions in Mapping Global Airline Geographies," *Annals of the Association of America Geographers* 96:3 (2006) 471–490.

M. Zook and M. Graham, "The Creative Reconstruction of the Internet: Google and the Privatization of Cyberspace and Digiplace," *Geoforum* 38 (2007) 1322–1343.