From Podes to Antipodes:
New Dimensions in Mapping Global Time, Cost, and Distance

by
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Paper prepared for
Specialist Workshop on Globalization in the World-System: Mapping Change over Time

University of California, Riverside
February 7-8, 2004

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> "There is no doubt that geography is going to help aviation, and aviation help geography in the same way. The importance to the Empire of the development of aviation is obvious…It is certainly very tantalizing to me to have seen all those red lines on the maps, and to think that later on it may be possible for me to be able to fly round the Empire instead of going by sea.
>
> The Price of Wales in (Prince of Wales *et al*, 1920)

> "I have often thought the British Empire, in so far as Egypt, India, Australia, Africa and South Africa are concerned, is like some great giant whose head is in England, whose enormous limbs stretch from Cairo to Australia and Cairo to the Cape, whose veins are these air routes, whose arteries are these great air organizations described…By such means shall we confer on our kinsmen overseas the priceless gift of close inter-communication which is the bed-rock of Imperial affection and commercial prosperity."
>
> Air Vice Marshall Sir Geoffrey Salmond in (Prince of Wales *et al*, 1920)

Human curiosity about traveling to and communicating with places near and distant usually raises three perplexing questions: How far is it from Point A to Point B? How long does it take to travel or communicate between these two points? And, what is the cost? These questions were raised by the earliest humans who were interested in exploring nearby familiar or distant unfamiliar places. They are exactly the same questions that stimulated explorations and discoveries of unknown continents, seas, and worlds for the past several millennia. And these same questions about time, distance, and cost surface when we listen to possibilities about traveling to or communicating with other planets and universes (Davis, 2000). Regardless of what stage we are in human history or where we are when we ask these questions, perceptions of distance shapes our understanding of places and worlds.

Advances in technology, most notably long range airliners and telecommunications, have drastically reduced the time and cost dimensions of distance. So much so that some have brazenly declared the death of distance particularly vis-à-vis communications (Cairncross, 1997). Although there is an ongoing debate of how information technologies are affecting distance and geography (a topic that is not fully explored in this paper), people remain corporal creatures with clear emotional, social and economic reasons for physically traveling from place to place. Although more constrained than the flows of capital, information and goods; the time and cost of moving from Point A to Point B is central to how people conceive of distance in the globalizing world.[1]

[1] It is important to note that this paper considers travel distance solely on the dimensions of time and cost without taking into account other clearly relevant (yet harder to quantify) measures such as political and visa distance, cultural distance, and gendered distance.

Therefore, in this paper we examine the distances between a number of continental and world cities, the costs of moving between them, and the time required to travel between them. There are a number of overriding questions we seek answers both in our analysis and also the depiction of results. They are:

- What are the most accessible cities, as measured by the shortest amount of time to reach them? And, correspondingly, what are the least accessible cities?
- What cities are closest and most in combined aggregate distance between them and, correspondingly, which are the most distant from all other cities?
- Of the world cities we consider, which have the lowest aggregate cost between them and which are the most expensive?
- Which world regions, for example, Europe or South American or Middle East/North Africa, have world cities that are most and least accessible, least and most expensive? What does a regional analysis of the data reveal?
- Are there any discernible relationships between our main variables, time, cost, and distance for individual cities on a global scale or regional scale?

We realize in undertaking this effort that the plastic fluid worlds that exist and that are emerging are not only a different world than what existed two thousand or two hundred years ago but is distinct from the world of even twenty years ago.

Thinking about Time, Space and Distance

In thinking about global systems of time, cost, distance, and accessibility, we draw on a range of intersecting literature that includes statistical geography, non-Euclian geometry and geography, time geography, urban geography and world cities, the geographies of transportation, information and communications, network theory and world systems analysis, e-commerce and cyberspace, and imaginative cartography. It is in exploring these interstices that we find the places and spaces to study concepts, theories, and models of human spatial movement, the intersections of time, cost, and distance, and the creation of some innovative ways of presenting the data and relationships.

A central cluster of scholarship for this research is the "global" or "world cities" literature. Early work on this topic was conducted by **Peter Hall (1966, 1984**). Among the questions raised sociologists, geographers, economists, and those in marketing and information science are how to classify and rank the world's largest cities. A variety of criteria are used, including standard measures such as population size and number of head offices of transnational firms, but also number of flights departing and arriving, passenger volume, and specific services, including major sporting events, major conferences, and specialized service economies, such as banking and advertising establishments. A careful reading of this literature reveals there is no agreement on either the best criteria to measure globalness, the labels to give highly ranked cities, and the first and second tiers of global or world cities. See, for example, the studies by **Friedman and Wolff 1982; Friedmann 1986, 1995; Knox 1994; Smith 1996; Short and Kim 1999; Lo and Yeung, 1998; Lo and Marcotullio 1998, 2001; Hill and Kim 2000; Kick and Davis 2001; Sassen 2001; Scott 2001; GaWC website**). Some of the recent urban work is linked to world systems thinking, especially attempts to define and measure core, semiperiphery, and periphery cities and regions, the geographies and geometries of urban networks, and globalization. See **Hargittai and Centeno** (2001) and **Smith and Timerlake** (2001).

More recent contributions within the communications distance realm are those focusing specifically on ICT economies (see chapters in **Wheeler, Aoyama and Warf 2000; also in Leinbach and Brunn 2001; Castells, 1989 & 1996**). Geographers among others have begun to look at the worlds of flows, linkages, networks, and patterns of individual corporations, countries, and cities (**Warf 1995; Graham and Marvin 1996**; **Castells 2000**; **Langdale 1991, 2000**; **Malecki and Gorman 2000**; **Murnion 2000**; **Brunn and Dodge 2001; Leinbach and Brunn 2001; Sacks et al. 2001; Townsend 2001; Edwards 2001; Leinbach and Brunn 2002; Saad, House, and Brunn 2002: Kellerman 2002**). A variety of criteria are used including the number of hyperlinks or URL references for specific cities and the number of paired hyperlinks between major cities in a region (**Brunn 2003**). Location of hosts and domain names (for example, (**Sui 2000)**, innovative and laggard regions (**Zook 2001, 2002**), real estate (**Dodge and Shiode 2000; Palm and Danis 2002**), web factories (**Gorman 2002),** and international development (**Wilson 2001**) are among the other themes.

Representations of Time, Space and Distance

A central challenge for all these literatures is how to illustrate these concepts of time, distance, and cost for the user of such information. To illustrate them is to provide a means of communicating or conveying their meaning, just as much to the explorer and discover in all of us or to the casual user who wants to be able to navigate and be comfortable in that navigation. Maps are heuristic and graphic representations of location-based features. Whether these maps are full of many minutiae in local spaces or unknown terra incognitae on oceans or continents (or even in outer space today), they are instruments or communication devises designed to help us understand places near and distant. And that understanding extends to helping us know what it is like to move or communicate between two points. Those two points may be known or unknown, or one place know and the other unknown.

It is traversing or traveling between and origin and destination where the issues or elements of distance, time, and cost are raised. That travel may be on foot, cart or stagecoach, horse or camel, steamship or train, slow or fast moving motor vehicle, or slow or fast moving aircraft. Whether one historically was traveling by horseback or covered wagon, questions about how far away was the destination, how long would it take to get there, and what costs were incurred usually were asked or considered before departure. And the same questions are being asked today by those choosing to fly between major continental or global cities or between small cities within a given country. In truth, the world's daily travel movements and human circulations include the planet's residents moving between sets of points or among multiple sets of points using all manner of modes. Horses, camels, two-wheeled carts, horses and carts are used in many of the same countries as those flying supersonic aircraft. It is in advanced technologically oriented societies where issues of time, cost, and distance are considered paramount for those conducting continental and global transactions, whether for industry, leisure, disaster relief, warfare, or governmental programs.

Geographers and cartographers have long-standing and vested interests in the questions raised above, not only because of their pursuit to learn more about places and their meanings, but to present or represent that information to enhance our understanding. For many geographers, the cartography side of the ledger is part of their disciplinary training and way of communicating their knowledge about places, interaction, and circulation. Geographers would also be among the first to recognize that advances in transportation and communication technologies, especially electronic technologies, have meant that we need to represent locations and places using some new and different cartographic methods. These space-adjusting technologies just alluded to, have meant that absolute space is replaced by relative space in the minds of those mixing or wishing to move between or across spaces. It is mapping these worlds of relative space that have become major challenges for geographers and cartographers.

The major questions that persist in mapping relative worlds, or a world of points, nodes, and networks that are transportation and communications-based, include: how can these features be mapped? Or to state it another way, how can we "map" distance, time, and cost between two places or multiple locations? Absolute distances between Point A and Point B will provide one valuable piece of information we might like to know. But more important in a rapidly changing, fast-paced, and international world of major nodes (corporate headquarters, major universities, capital cities, tourist destinations, etc.) are questions about the cost of moving from Point A to Point B. Probably for many travelers, cost considerations override distance, since all travel distances are relative these days. And for many who travel, time is a more important concern, that is, how long will it take to move from Point A to Point B? Many travelers would also consider time above cost in importance.

The earlier work of **William Warntz** was insightful in exploring conceptual schema and cartographic representation of megageography datasets and the tyranny of space concept (Warntz 1968). His pioneering work looking at potential maps, income fronts, and the poles of human condition reveal spaces (U.S. or the world) with a series of peaks and sinks or ridges and troughs (see, for example, Warntz , 1975). Further development in our thinking about space-adjusting technologies and conceptual frameworks for looking at shrinking worlds, as measured in transportation and communications times and distance, were set forth by **Don Janelle** and his developing the terms time-space convergence, cost-space convergence, and human extensibility (Janelle 1968, 1973, 1975, 1991). These concepts were used by Janelle to explore the time needed to move from place to place with improved transportation and communications. **Ron Abler** in his early work on communications geography, especially the national postal and telephone system, was another contributor introducing these technology dimensions about time and space into the geography community (Abler 1968, 1971, 1991). Much of this thinking about the collapsing of space and time, and the impacts this meshing of time and space have on local firms, individual countries, and major regions were included in **Brunn and Leinbach** (1991). Many of the eighteen chapters in this initial volume on the geography of information and communication addressed issues about shrinking time and space.

A second group of scholars were concerned about broad issue the space/time nexus, including how to map or graphically illustrate patterns and processes (**Carlstein, Parkes, and Thrift** 1978). A number of scholars during the 1970s, 1980s and 1990s, including geographers and others with spatial perspectives, introduced some new and imaginative ways to map spaces and also time/space relations, time regions, and accessibility (see, for example, **Doxiadis 1970; McHale 1972; Gould 1991, Forer and Parrott 1991, Langdale 1991, Lewis and Van Dusen Mukaida 1991; Ward 1989; Adams 1998, 2000; Brunn 2000; Dodge 2000; Forer and Huisman 2000; Kwan 2000; Wilson and Arrowsmith 2000; Brunn and Ghose 2003**). More recently through the uses of high speed computers that are able to handle large datasets, additional creative mapping efforts have appeared (see**, Dodge and Kitchin, 2000, 2001**)

Thinking about and Representing Global Air Travel

Building upon these conceptions of ranked world cities and representation of space and time, this paper presents an analysis and representation of the distance (physical, cost and time) between world and continental cities as represented by airline travel.[2] Even prior to the boom in air travel at the end of World War II (Taaffe, 1959), geographers were considering the implications of the technological innovation of civilian air travel on perceptions and representations of distance.[3] "It is a very flat world we live on, it is a two-dimensional space bent in a third dimension, the same way that we are told that space is a three-dimensional world bent in a fourth. Take a globe and put a pin firmly at London, then attach a piece of cotton to it, and follow out the shortest routes from point to point….on the ordinary map the route New York-London does not go directly over Newfoundland, but that is the direct route." (Geography of Post-War Air Routes, 1944) (See also Plischke, 1943 and de Seversky, 1950).

In the Presidential address to the AAG in Knoxville, TN in 1945, Platt (1946) notes that commercial airline travel mirrors surface travel with relatively few exceptions. Moreover he argues that aviation has a powerful unifying force, "Aviation over the world is cut from one piece of cloth; it is of one cultural variety. Even more than is usual in elements belonging to one type of culture the features of aviation are nearly identical over the world, the parts interchangeable." (Platt, 1946; 8). Recognizing the dynamism and fragility of global airline systems (particularly germane given the disruption of civilian travel during the war) Platt focuses on how the global, the local and the glocal (our terminology not his) coincided in the place of the Chicago airport and surrounding communities. In so doing, he asks questions that resonate today in how we think about representing and interacting with global air travel.[4]

The empirical analyses that emerged at this time relied upon available information on airports and established routes and schedules (Wilcox, 1930; Pollog, 1937; Geography of Post-War Air Routes, 1944; Kish, 1958; Pearcy and Alexander, 1951 & 1953).[5] Although admittedly crude proxies for travel, they allowed researchers to identify important patterns in air travel such as replicating existing systems of travel and communications, the role of population for generating demand, and the special exceptions exhibited by certain place due to special economic, political or tourism functions. (Pollog, 1937; Pearcy and Alexander, 1951). Using better measures of air travel (*i.e.* passenger volumes), Taaffe (1956, 1959, 1962) also emphasizes the connection between urban populations and demand for air travel. "Thus an analysis of eight maps indicates that the two primary factors in the development of the air passenger pattern of the United States have been urban population and urban grouping; the two secondary factors have been urban function and overnight rail service." (Taaffe, 1956; 237). Taaffe (1956, 1959) also noted the

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[2] Although in this paper we primarily consider air travel as a measure of travel distance, it is also an important aspect of communication distance (*i.e.*, airmail, overnight express of original documents, etc.). In fact, the transportation of mail was the earliest commercial use of airplanes (Air Ministry, 1919; Prince of Wales *et al*, 1920).

[3] In fact, the topic of routing of international air travel can be traced back to immediately following the first World War (Air Ministry, 1919; Prince of Wales *et al*, 1920) and throughout the 1920s, 1930s and 1940s (Wilcox, 1930; Mason, 1936; Pollog, 1937; Van Zandt, 1944; Whittlesey *et al*, 1947).

[4] "On the one hand, how shall we arrange our far-reaching activities, our world-wide interdependence, now calling for split-second cooperation and presupposing universal agreement on objectives and means of attaining them? On the other hand, how shall we provide for individual human beings and their local initiative in their immediate surroundings, now threatened with submergence in a world of total organization and centralized control?" (Platt, 1946; 12).

[5] The authors cannot help but note the similarities between these efforts and maps and similar efforts made close to fifty years later to represent the geography of the Internet by using domain names and bandwidth.

considerable variation in these patterns such as the higher rate of passenger travel in the manufacturing belt than would have been expected given its population.

Although a significant corpus of literature on air travel (see Sealey, 1966 & 1967; Taaffe and Gauthier, 1973 for examples and reviews) has been produced since these early efforts, the measures (passenger volumes or scheduled flights) and representations of global air travel (route maps and city hierarchies) have remained relatively constant (Smith and Timberlake, 2001; Bowen, 2000).[6] In the past two decades, many studies have focused on questions of how and why these global patterns develop and include the variables of state action, market structure and regulation. For example, Bowen and Leinbach (1995) and Bowen (2000) examine the development of airline travel within Southeast Asia and the role of the state and Goetz (2002), Goetz and Vowles (2000), Goetz and Sutton (1997), Kessides (1993) Brueckner, Dyer and Spiller (1992), and Borenstein (1989) have looked closely the deregulation of the US airline industry with special attention to how market conditions can increase oligopolistic control over certain cities and routes and in so doing raise cost. Most relevant to this paper are efforts to compare the connectivity and relative changes in traffic of world cities with a particular eye on how this interacts with globalization (Smith and Timberlake, 2001; O'Connor, 2003). For example, O'Connor (2003) finds that during the 1990s airline passenger movement has experience a dispersion to secondary cities.

Description of the Data and its Generation

The data used in this paper were gathered by using an automated program that replicates the pattern used by individuals to conduct searches for flights via a major web-based travel service.[7] The travel service is based in the United States and is available to any web user, *i.e.*, no special access such as travel agent status is required. Although we originally wished to create a data matrix for flight information between the 200 largest cities worldwide, it quickly became apparent that creating a 40,000 cell matrix would be unworkable.

For this reason we chose an alternative methodology of gathering flight data to destination cities from 14 global hub airports. This group of hub airports is based on Smith and Timberlake's (2001) 1997 rankings of international passenger flows between airports.[8] We selected the top eleven cities from this ranking in order to include all three of Sassen's (2001) global cities. In order to provide geographic diversity the top ranked city from each continent not represented by the top eleven hubs (Africa, South America and Australia) were also included. The data are summarized in the table below. Although this group of global hubs is open to critique, *e.g.*, the strong European focus, it reflects the nature of the global airline system and provides a meaningful and achievable look at patterns within global airline travel.

[6] In his review of inter-regional flow data Thompson (1974; 569) notes that data on passenger air travel "is perhaps the best spatial interaction matrix available."

[7] It is important to note that the data used in this paper reflects the results of one web-based travel service which will not produce all possible routings and flight options between city pairs. There is no single system for airline searches and bookings with active competition between the three main systems, Sabre, Amadeus, and Galileo.

[8] This data can also be downloaded from the GaWC website (http://www.lboro.ac.uk/gawc/datasets/da10.html).

Table 1, 14 Hub Cities

City	Airport Code [9]	Smith and Timberlake (2001) Rank	Smith and Timberlake (2001) Network Eigenvalue
London	LON	1	1
Frankfurt	FRA	2	0.859
Paris	PAR	3	0.767
New York	NYC	4	0.672
Amsterdam	AMS	5	0.614
Miami	MIA	6	0.533
Zurich	ZRH	7	0.533
Los Angeles	LAX	8	0.516
Hong Kong	HKG	9	0.515
Singapore	SIN	10	0.502
Tokyo	TYO	11	0.494
Buenos Aires	EZE	29	0.282
Sydney	SYD	30	0.277
Johannesburg	JNB	67	0.101

Data on flights from these 14 hub cities to approximately 200 destination cities (which included the 14 hub cities) were conducted. Destination cities were selected if (1) they had a 2000 population of more than two million inhabitants based on United Nations World Urbanization Prospects (2001) figures or (2) were the capital of a country. If a single country had more than three cities with more than 2 million inhabitants, only cities with more than 5 million inhabitants were included.[10] These steps were taken in order to create a list of cities that was inclusive of all countries while not too large to create problems in gathering the data. This resulted in approximately 2800 unique flights between the 14 hub and the 200 destination cities.

These searches for these flights were conducted by an automated program (a perl based script) run on December 10th and 11th, 2003 on a desktop computer based in Lexington, KY. The queries were conducted over two days in order to limit the load on the travel search engine and amounted to about 60 queries an hour. Although flight prices are constantly subject to change, their impact on the dataset was slight. Comparison of several randomly selected flights that were queried repeatedly over the course of data run revealed no to minimum changes in pricing and time.

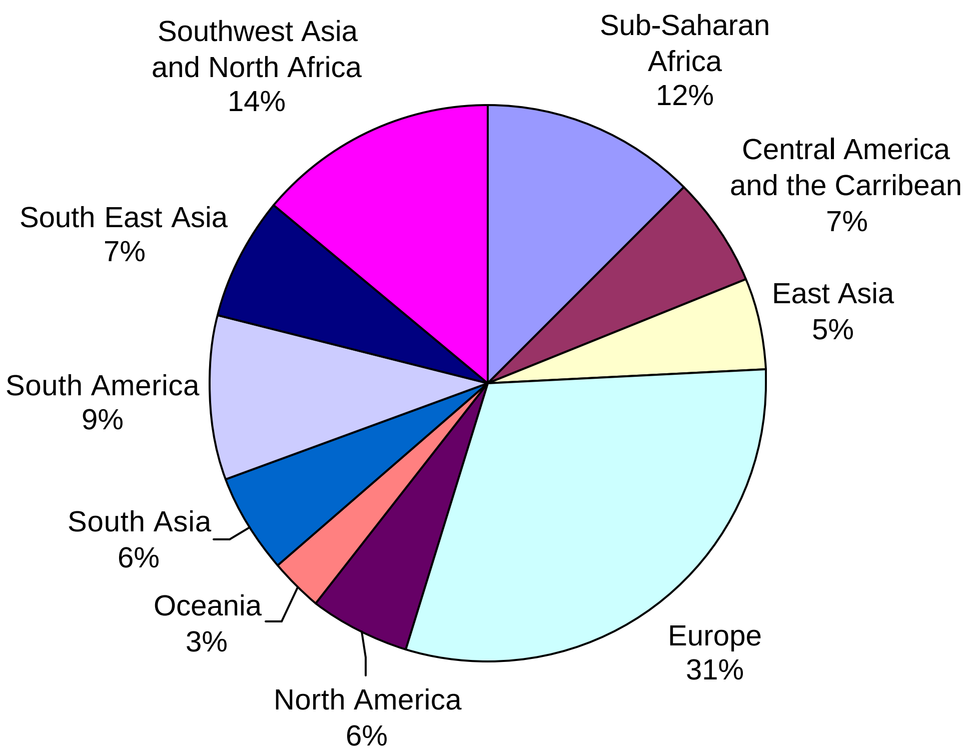
The queries were conducted with the hub city as the departure airport for round-trip travel to each destination city. Queries were constructed for flights leaving January 6, 2004 (Tuesday) and returning January 13, 2004 (Tuesday) with flight times around noon. They also included all possible airlines and routings. Generally each query returned up to 15 different flight possibilities and included information on round-trip price, duration of flights both to and from destination city, routing of flight, and airline. These data were captured and parsed for each flight. From these flights the minimum cost and time (not generally the same flight) between the

[9] In some cases rather than using a specific airport code, a more general code that covered two or more airports within a global hub was used. These include London (LON=Heathrow and Gatwick), Paris (PAR= Charles Degaulle and Orly), New York (NYC=JFK, Newark and LaGuardia), and Tokyo (TYO= Haneda and Narita).
[10] This affected Brazil, China, Germany, India, Japan and the United States.

hub and destination cities was identified. In a parallel effort, the distance between each hub and destination city (based the great circle distance between airport codes) was also gathered.

Because of limitations of the web-based search engine (it did not return valid flight between every hub city and destination city) and issues within flight schedules (some destination cities did not have service to them on the dates searched) only 137 destination cities are included in the analysis below. See the Appendix for the listing of all 137 cities and their associated airport codes. While less than the initial number of cities, this data set provides a nuanced picture of the structure of global airline travel. The distribution of the cities by global regions is outlined below.

Figure 1, Destination Cities by Region (n = 137)



Data Analysis

This analysis is based on three interlocked yet unique measurements of distance (physical, cost and time) between the 14 hub cities and the 137 destination cities. Physical distance (based on great circle distance) is readily understood and is expressed in kilometers. Cost distance (expressed in dollars) represents the least expensive flight between city pairs and time distance (expressed in minutes) represents the minimum amount of time required to fly back and forth between city pairs.[11]

Summation of Physical, Cost and Time Distance

For each destination city the summed distance for cost and time was divided by the number of hub cities for which data were obtained (generally 14 hubs but in one or two cases as few as 8) to produce the relevant average distance to hub cities. The data are summarized in Table 2 and listed for only the top and bottom 20 cities (Appendix B).

An obvious conclusion from these tables is that it reflects the construction of the 14 hub cities (with 5 in Europe) which in turn reflects the global airline system, *i.e.*, the cities with the smaller average distances of all types (physical, cost and time) are all European capitals and cities with the largest average distances are generally in the southern hemisphere and/or in what is commonly considered the periphery of the global system. While useful, the cost and time distances per hub simply reflect that cities that are far away in a physical sense are also far away in a cost and time sense.

Table 2, City Physical, Cost and Time Distance

	Physical Distance per Hub City (km)	Cost Distance per Hub City ($)	Time Distance per Hub City (minutes)
Mean	8,359	2,146	1,806
Standard Deviation	1,457	879	383
Maximum	12,880	5,324	2,618
City	Aukland, New Zealand	Paramaribo, Suriname	Montevideo, Uruguay
Minimum	6,447	1,031	1,077
City	Amsterdam, The Netherlands	Paris, France	London, UK

Thus, it is important to standardize the cost and time distance for cities by the physical distance to these cities. This allows one to distinguish between cities that are distant (in terms of cost or time) simply because they are physically distant and cities relatively more difficult to get to (in terms of cost or time) than their physical location would suggest. The data are summarized below and provided for the top and bottom 20 cities in Appendix B.

[11] Time distance is based on the amount of travel time both outbound from and inbound to a hub city and a destination city in order to compensate for difference in westward vs. eastward travel time due to prevailing wind patterns (See Warntz, 1961).

Table 3, City Cost and Time Distance Standardized by Physical Distance

	Cost Distance per Hub City per Physical Distance ($ / km)	Time Distance per Hub City per Physical Distance (minutes / km)
Mean	0.26	0.22
Standard Deviation	0.09	0.03
Maximum	0.56	0.31
City	Luanda, Angola	Nizhni Novgorod, Russia
Minimum	0.13	0.16
City	Singapore	New York, USA

This perspective provides a decidedly different picture of distance to cities. Although many of the most distant cities remain in the southern hemisphere one also sees pockets of "distant" cities in the former Soviet Union as well as other locations. Moreover, while the most central cities continue to include European capitals, Asian, North American and Oceania cities also appear as being highly ranked.

Explaining Cost and Time Distance

Although physical distance between cities remains constant, cost and time distance depends on the global airline system which in turn depends on the dynamic structure of globalization. A city such as Tbilisi, Georgia or Tirana, Albania may be relatively close physically to important global centers in Europe but nonetheless is relatively peripheral (in terms of cost and time) to the global airline system. Any number of factors can contribute to the centrality or peripherality of a particular city, including physical distance, size of the city and connection/role to the global economy.

In an effort to understand the factors associated with time and cost distance, a series of multivariate regressions were conducted for the destination cities in the dataset. Two measures of distance were used as dependent variables (1) **Cost Distance per Hub City ($)** and (2) **Time Distance per Hub City (minutes)**. These were each regressed against (a) **Physical Distance per Hub City (km)**, (b) **Number of Inhabitants (000s)**, and (c) **Number of Internet Domain Names in July 2001**. The first independent variable controls for the observed relationship between physical vs. time/cost distance, the second provides a measure of demand for travel (Taaffe, 1956), and the third is an indicator of a city's relative integration to the global economy. As argued elsewhere (Zook, 2001), Internet domain names are indicative of a country's (or in this case a city's) ability to connect and communicate with the rest of the world.

The models and relevant statistical data are summarized below.

Table 4, Model results

	DEPENDENT VARIABLES			
	Time Distance per Hub City		Cost Distance per Hub City	
	ß	*t*	*ß*	*t*
Physical Distance per Hub City (km)	0.206	15.73	0.225	6.63
Number of Inhabitants (000s)	(0.0108)	-2.38	(0.005)	-0.39
Number of Internet Domain Names, (July 2001)	(0.00032)	-3.69	(0.00072)	-3.28
Constant	117.66		146.52	
n	106		106	
Adj R^2	0.728		0.362	

Through the use of these simple models a number of observations become readily apparent. First, the independent variables do a much better job of explaining variation in time distance than in cost distance (72.8 percent of the variation vs. 36.2 percent). This finding suggests that time distance is much more a direct function of physical distance than is cost distance. In fact when the two dependent variables are regressed solely against physical distance it explains 61.3 and 24.4 percent of the variation in time and cost distance respectively. This finding corresponds well to the interpretation that cost distance is more of a matter of connection to the global economy than physical distance *per se*.

Second, while the size of the destination cities emerges as a significant variable in time distance, it does not for cost distance. This observation again suggests that connectivity to the global system is a more important factor in explaining cost distance than simple population size. Although developing country cities are among the largest in the world, their populations are not integrated into the global airline system. In short, while they are urbanized, they are not globalized.

Although connection to the global economy can be measured by any number of ways (imports/exports, minutes of phone traffic, etc.) data on a relatively few of these measures are available at the city level. The one measure used in these models (number of domain names) does emerge as being significant in both models. Despite this significance and the addition to the explanatory power of the second model, the majority of the variation in cost distance remains unexplained. While some of the unexplained variance no doubt is do with the structure of the international airline industry (*e.g.*, national regulatory structures) and greater geo-political issues, we plan to explore additional city-level measures of connection to the global system as an avenue for improving these models.

<u>Representing Physical, Cost and Time Distance</u>

To supplement the tabular data and statistical results above, we prepared two sets of maps and diagrams depicting the patters of airline travel to and from the 14 global air hubs and 137 destination cities. The first set (Figures 2-6) illustrate on world maps the following relationships,

- ? Average distance from hubs
- ? Average cost per hub
- ? Average time per hub
- ? Average cost per hub per kilometer
- ? Average time per hub per kilometer

Cities are assigned to a category by quantile breaks and various sizes and colors are used to illustrate the given relationships. Each of the 137 destination cities can be compared with all others. These maps, with faint outlines of countries and continents, are constructed to downplay absolute space on a global scale, but more illustrate the point made above that we are moving into "a world of points." The second set of three scattergrams (Figures 7-9) depict the cost, time, and variables mentioned above. These scattergrams are used to identify the location and extent of cities in ten major world regions.

The patterns on Figure 2, **Average Distance from Hubs**, is not surprising. Since most of the major hubs are European cities, it is expected that of the 137 destination cities, most would be closer to those European hubs. The distant ones, again as expected, are in peripheries of East Asia, southern Africa, and South America. A number of major destination cities in northeast U.S. and southeast Canada are roughly the same distance from European cities as those in Southwest Asia and South Asia. Based on our findings, the most distant cities were Auckland (12,880 km), Melbourne (12,290 km), Sydney (12,217 km), and Santiago, Chile (11,225). And the closest were Amsterdam (6,447 km), Brussels (6,451 km), London (6,491), and Paris (6,492).

The patterns on Figure 3, **Average Cost per Hub**, have some parallels to Figure 1, in that those destination cities more distance are often the most expensive to travel. The highest costs are those large cities in southern South America, western, central, and southern Africa, and southern Asia. The largest destination cities in western North American and eastern Asia, as well as Singapore, Melbourne and Sydney, are in the same cost category as those cities in North Africa and northern Europe. The lowest cost cities were Paris ($1,301), Amsterdam ($1,078), Prague and Dublin (each $1,092). Those most expensive cities to travel to and from were Paramaribo, Suriname ($5,327), Luanda, Angola ($5,263), Lilongwe, Malawi ($4,627), Kigali, Rwanda ($4,483), and Port Moresby, Papua New Guinea ($4,302).

Average Time per Hub is depicted on Figure 4. Some of the patterns are similar to the "distance" map (Figure 1), especially southern Africa, Oceania, and South America, while others are more similar to the "cost" map (Figure 2), especially in Europe, Southwest Asia, and South Asia. The cities that can be reached in the shortest amount of time are, not surprisingly, all in Europe: London (1,077 minutes), Paris (1,086), Zurich (1,156), and Amsterdam (1.174 minutes). By contrast, which again comes as no surprise, are cities that are peripheral to the world's urban core: Montevideo, Uruguay (2,618 minutes), Asunción, Paraguay (2,611), La Paz, Bolivia (2,611), and Kigali, Rwanda (2,595 minutes).

The final two world maps (Figures 5 and 6) are summary maps that depict the **Average Time per Hub per Kilometer** and **Average Cost per Hub per Kilometer**. In the former, we observe that many of the major international cities that are far in distance from the European hubs, especially those in the United States, Canada, East Asia, and Oceania are easier to travel to and from than large destination cities in eastern and southeastern Europe, Central Asia. The regions with cities in a number of categories are in southern Africa (note the low value for Johannesburg), Central America (note the low value for Mexico City), and Southeast Asia (lowest values for Singapore, Kuala Lumpur, and Bangkok). The destination cities with the lowest average time per kilometer are: New York (0.163), Tokyo (0.164), London (0.166), and Paris (0.167), while those cities with the highest average times per kilometer are: Nizhni Novgorod (0.312), Kigali (0.307), Novosibirsk (0.290), and Kathmandu (0.284). The map depicting average cost per hub per kilometer (Figure 4) has some different patterns than Figure 5. The lowest costs are for those large destination cities in North America and East and Southeast Asia and the highest are in South Asia, southern and western Africa, and a half dozen cities in Central and South America. The cities with the lowest costs per kilometer are: Singapore ($0.129 per kilometer), Los Angeles ($0.145), New York ($0.147), and Tokyo and Shanghai both $0.149 per kilometer). By contrast the most expensive cities are: Luanda ($0.561 per kilometer), Kigali ($0.531), Paramaribo ($.497), and Lilongwe ($0.492).

The second set of graphics, as noted above, illustrate the geometric relationships between the variables described above (Figures 7-9). Each of the destination cities is represented by a symbol for the region in which it is located. Thus one can "read" these maps looking for distinctive regional patterns and for regions in which there are cities that have similar patterns to those elsewhere.[12] Ellipses were drawn to include the cities in each of ten regions. A small ellipse illustrates that the destination cities in that region are similar in the relationship depicted. A large ellipse illustrates the opposite, viz., a large variation in the relationships for the cities included in that region.

Some of the ellipses on these figures are what one would expect from the descriptions of Figures 2-6 above. Figure 7 shows the relationship between **Cost per Hub and Distance per Hub.** This pattern illustrates fairly distinct regional clusters; also there are few surprises. European, North African and Southwest Asian, East and South Asia, SubSaharan African, and Oceania cities are fairly distinctive. The smallest cluster is for East Asian cities followed by those cities in South Asia, and Europe. African cities (as noted by the size of the ellipse) illustrate the greatest variation followed by those cites in Oceania. In the latter region, as Figures 5 and 6 illustrate, those cities in Oceania are not only farther from the world's major hub cities, but also are among (African cities are more expensive) the most costly to travel. European cities are at the opposite end of the continuum, with lowest costs and shortest distance. The region which has some similarities to the most other regions is Southeast Asia, as there are cities with similar relationships to Central America, South Asia, and Southwest Asia. Overlapping ellipses also exist for Europe and North Africa and Southwest Asia, and North America and East Asia.

The relationship between **Time per Hub and Distance per Hub** is shown on Figure 8. This scattergram is much more complex than Figure 7 in that there are fewer distinctly homogeneous spaces for the cities in these ten regions. There is much overlapping of ellipses. While cities in

[12] We build upon other studies which have classified countries on the basis of GNP per capita, or trade flows, or membership in NGOs and IGOs. Some of these regionalization schemes are one-variable and rather elementary in their classifications, while others are multivariate. One of the more useful multivariate models was that advanced by **Brian Berry** in 1961 in his classification of the world's regions. Using 43 variables in a factor analytic model, he classified 95 countries using their factor scores on a demographic and economic factor. Each country was positioned on an X-Y axis and one could discern the location of each country and region on a continuum. One could use a similar schema to classify where a set of major continental, global, or world cities are with respect to all others.

Europe, Southwest Asia, and Oceania are fairly homogeneous in their city patterns, there is much diversity in other regions. There are destination cities in Africa, South America, Central America, South Asia, and Southeast Asia that have some similarities. The cities in East Asia are also among the most homogeneous, as they were in Figure 7. The region with the greatest variety of time/distance variations were South America followed by SubSaharan Africa.

The complexity of relationships is further illustrated on Figure 9, which shows the relations between **Time per Hub and Cost per Hub**. The maps depicting these relationships illustrated much overlapping of similar values, even cities in the same continent. That variation is illustrated on Figure 9 and especially for SubSaharan Africa. There are cities in this region that have similar values to those cities in South Asia and South America and Oceania. South America as a region has cities with readings similar to cities in Central America, South Asia, Oceania, Africa, and Southeast Asia. Also Southeast Asia has cities with readings similar to cities in five other regions. The region with the lowest costs and shortest time, not surprisingly, is Europe, followed next by North America. East Asia again is the most homogeneous region, followed by North America.

Conclusions and Future Directions

One of these most clear implications of the literature reviewed in this paper and the analysis and representation presented herein, is the paradox of continuity and dynamism exhibited in the globalization of transport and communications technologies. The comments made by the Prince of Wales and Air Vice Marshall Salmond over eighty years ago about the binding together of the British empire by air travel remain strikingly relevant even in post-Empire times (Prince of Wales *et al*, 1920). London and Europe remain central in terms of cost and time distance in the global system. Yet, new centers such as Beijing, Singapore and Seoul have also emerged reflecting the reality of close to a century of economic and political development. Rather than some technologically determined pathway, patterns of globalization are built upon complex interactions of agglomeration, interaction and marginalization.

Expectations during the late 1940s of the effect of the commercialization of a technology that had existed for decades (air travel) have clear parallels to expectations during the 1990s surrounding the commercialization of another technology which had emerged over decades (the network of networks known as the Internet). During the initial rush in the early 1950s airport facilities were developed worldwide and regular service established throughout the United States in a highly distributed fashion. (Pearcy and Alexander, 1951 & 1953; Taaffe, 1956). These initial expectations, however, far exceeded the actual use and geography of air travel. As Taaffe (1956; 225) notes, ""The early postwar period was one of premature expansion due to great optimism regarding the economic feasibility of providing air service to smaller cities. Heavy losses on lightly traveled routes resulted in the curtailment of many of these services. Among the factors increasing the importance during the later postwar period were the greater use of fast, four-engine planes, ill suited to short-haul flights, and the concentration of low-fare coach flights on the profitable routes between the larger centers. The lack of an economical short-haul aircraft has so far been the principle deterrent to the growth of air-passenger traffic at smaller cities."

Similarly, the diffusion of the Internet has fallen short of initial predictions and instead much of the infrastructure, content and commerce associated with it is concentrated in global cities (Dodge, 2000; Gorman, 2002; Malecki, 2002; Townsend, 2001; Zook 2001 & 2002). The rapid build out of the U.S.'s telecommunications network during the 1990s vastly overshot demand for it resulting in numerous bankruptcies in this sector. Nevertheless, the global system of air travel is dispersing to a range of smaller cities (O'Conner, 2003; Bowen, 2000) and has greatly increased the density of its networks over the past 50 years.

The research foci and questions raised in this paper, as noted, have a lengthy history in human geography inquire. The methodology used, the statistical results, and the graphics should stimulate some additional questions meriting research by those from different disciplines and perspectives. We suggest six that areas that will be productive for future inquiry.

- ? What kinds of patterns exist among the major destination cities? While we focus on cost and time distance for city pairs for major points of origin, the reverse side of the issue also begs for analysis. We not that the limitations of the search engine may preclude gathering these data..
- ? What kinds of seasonal differences exist? Seasonal variations should make some place closer and more distant depending upon the time of the year. Therefore, it would be important to repeat these searches several times during the course of a year to tease out places where there exist both stability and dynamism in the patterns.
- ? What would a series of time-cost-distance maps look like for internal travel among large and medium sized cities in a large country, such as Brazil, China, Russia, Canada, and Australia? And among ministates scattered over large territories, such as the Pacific Basin, or archipelagic states, such as Indonesia and the Philippines?
- ? What would the routing patterns look like? This fascinating topic has not been touched, but in preparing and examining the maps, we felt that these patterns are definitely worth exploring.
- ? How have issues of regulation changed the patterns? And also ICAO policies?
- ? How have recent developments in airline security affected patterns of air travel? What airports and regions have been most and least affected?

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Figure 2, Average Physical Distance (km) from Hub Cities

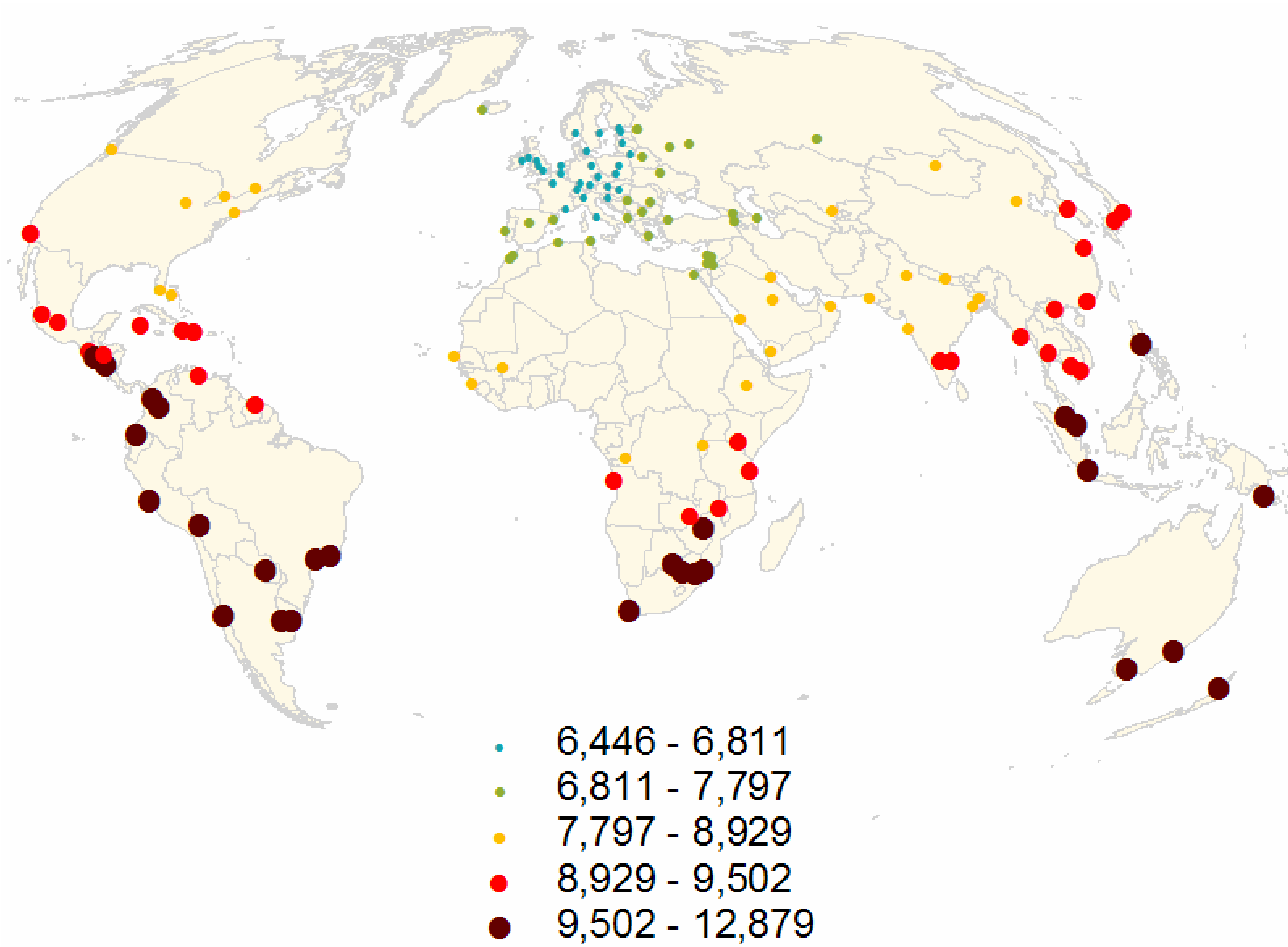


Figure 3, Average Cost Distance ($) from Hub Cities

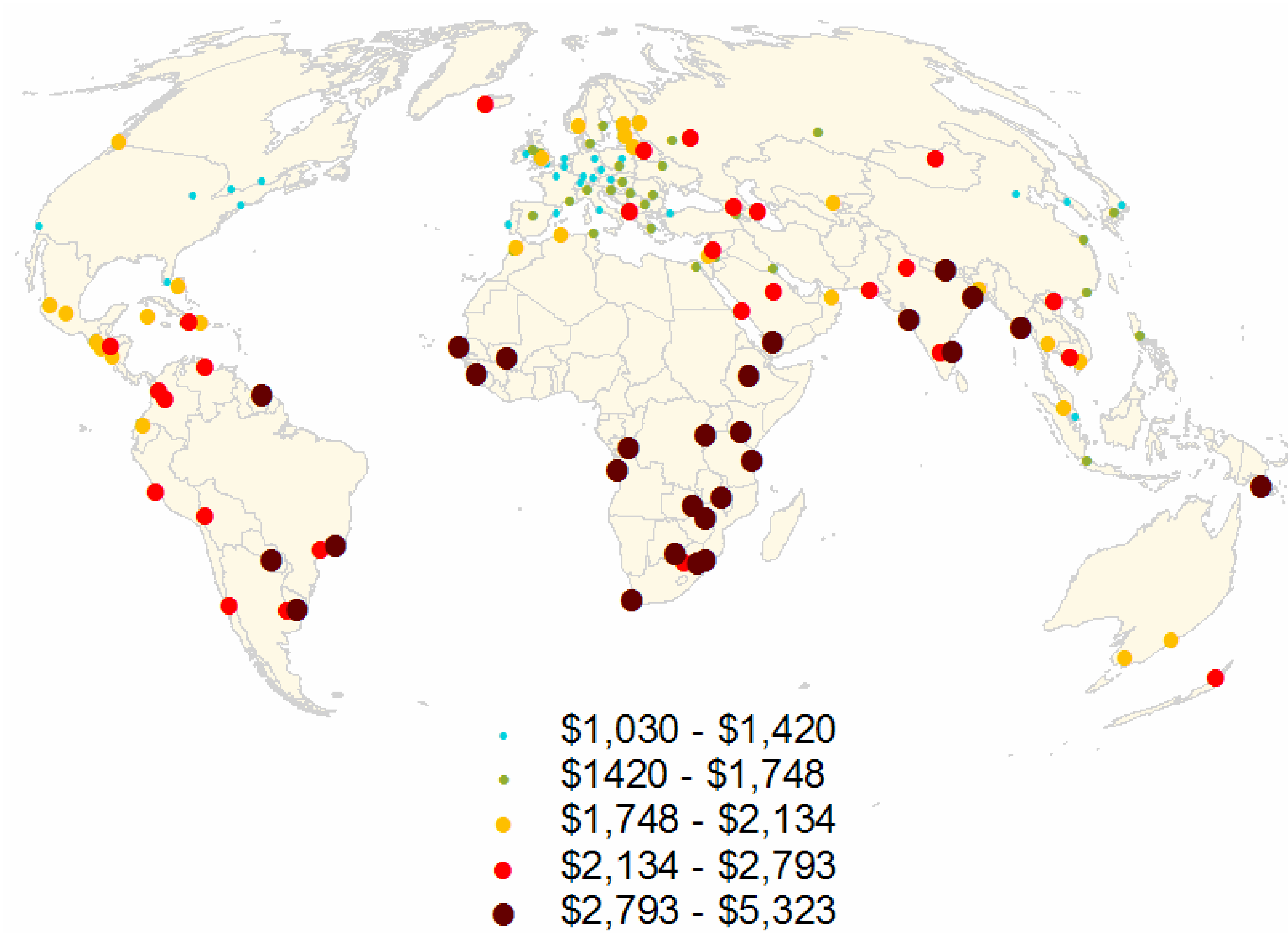


Figure 4, Average Time Distance (minutes) from Hub Cities

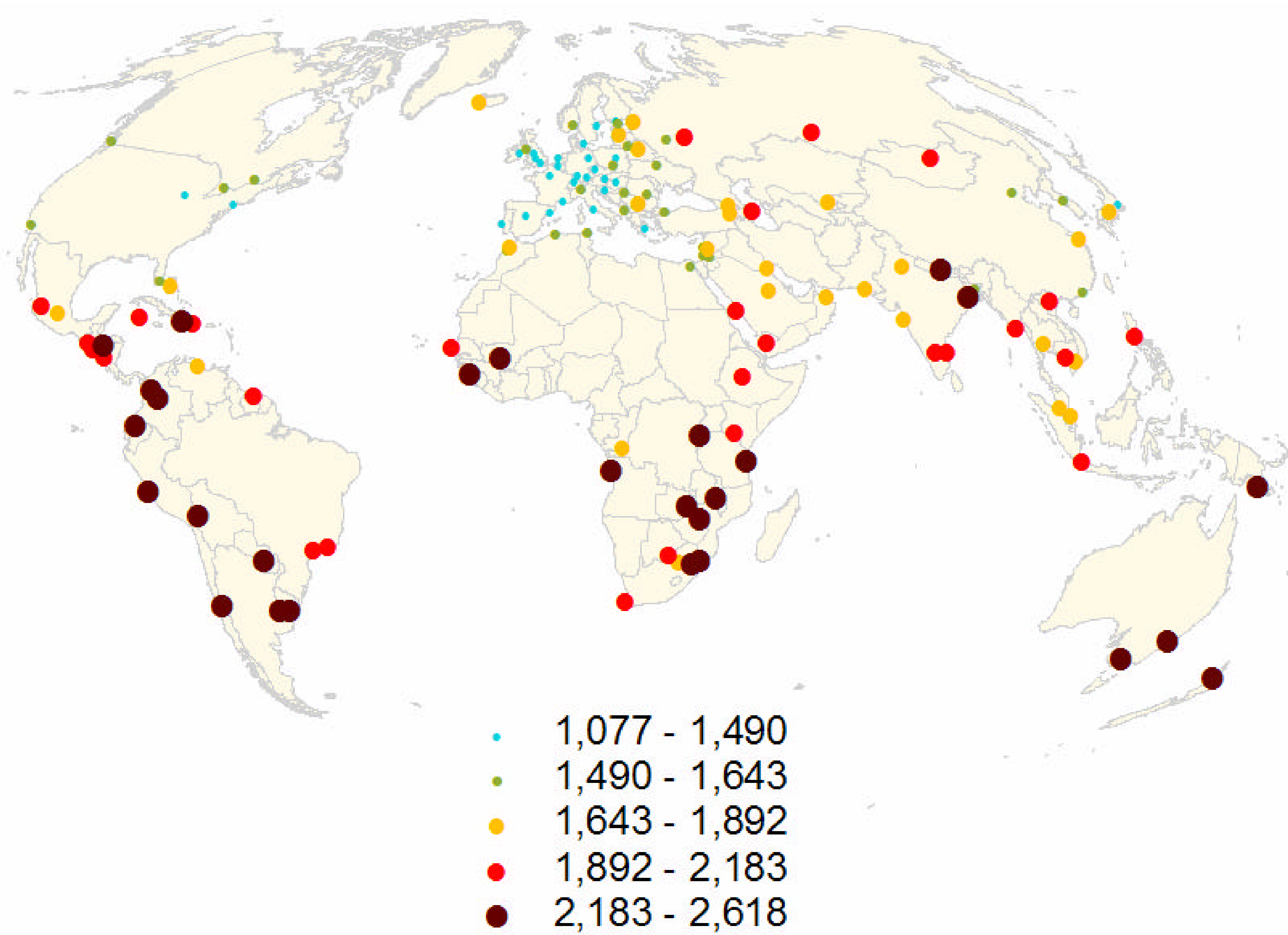


Figure 5, Average Time Distance per Hub per Kilometer (minutes per km)

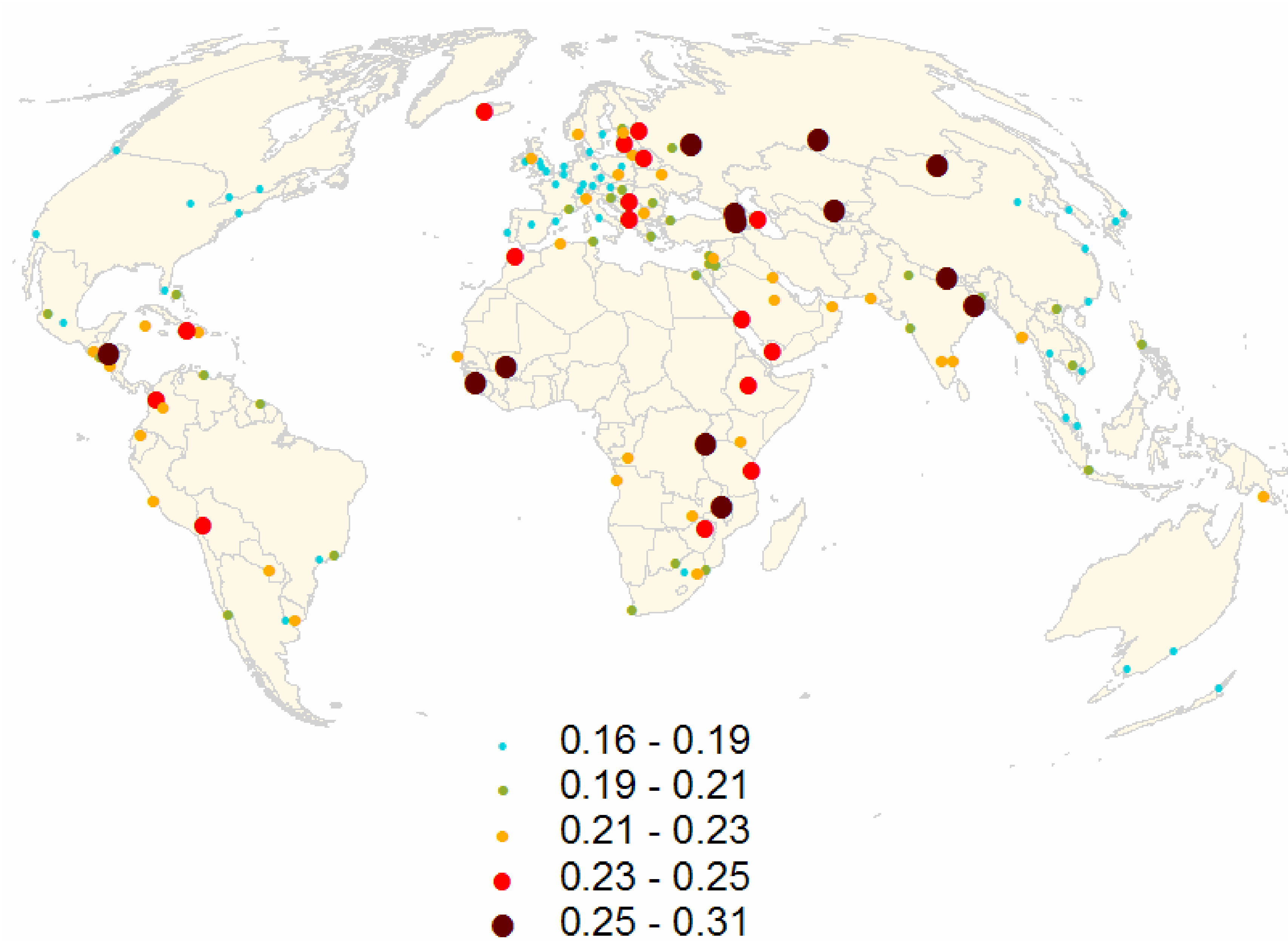


Figure 6, Average Cost Distance per Hub per Kilometer ($ per km)

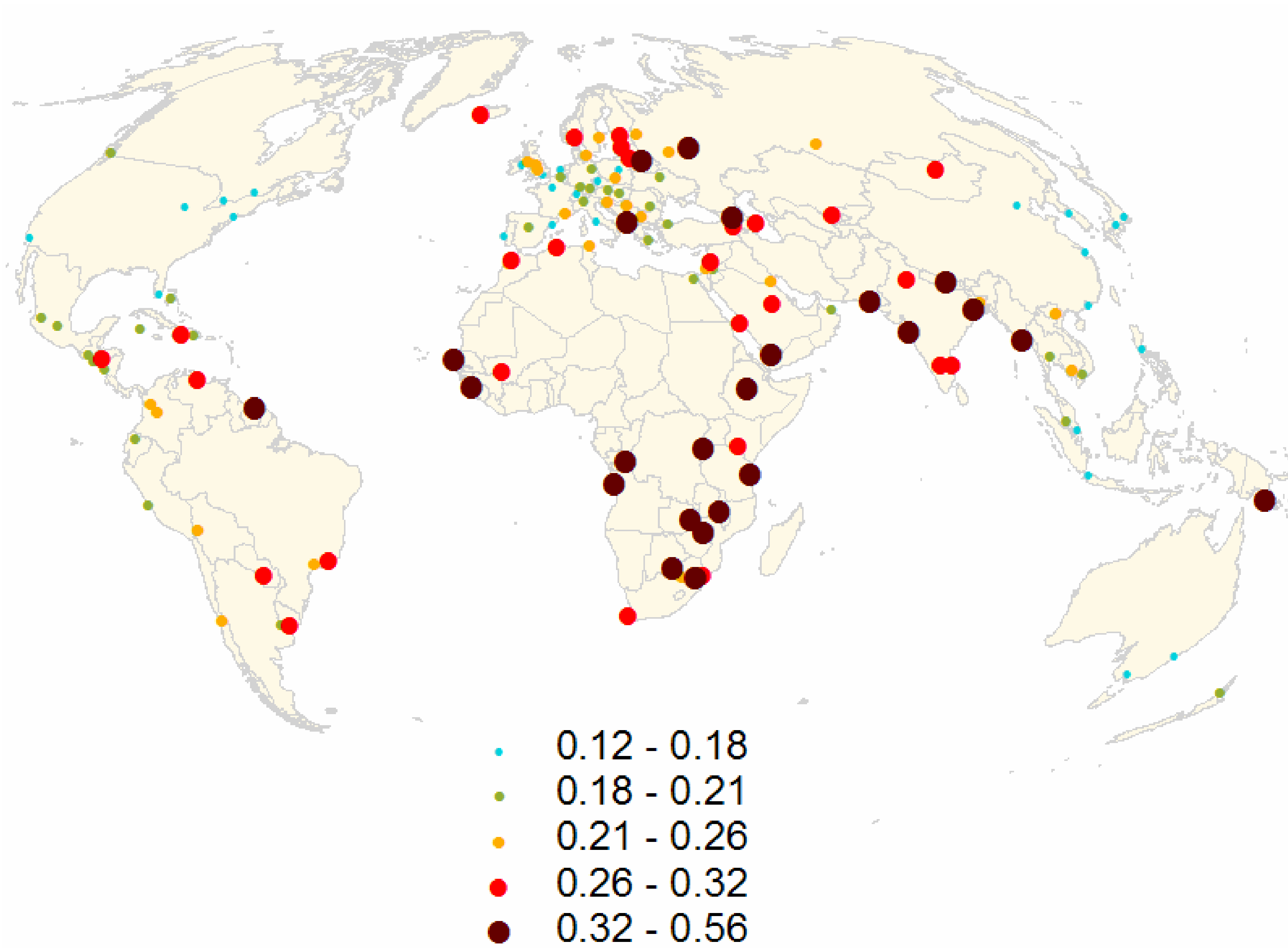


Figure 7, Cost per Hub and Distance per Hub

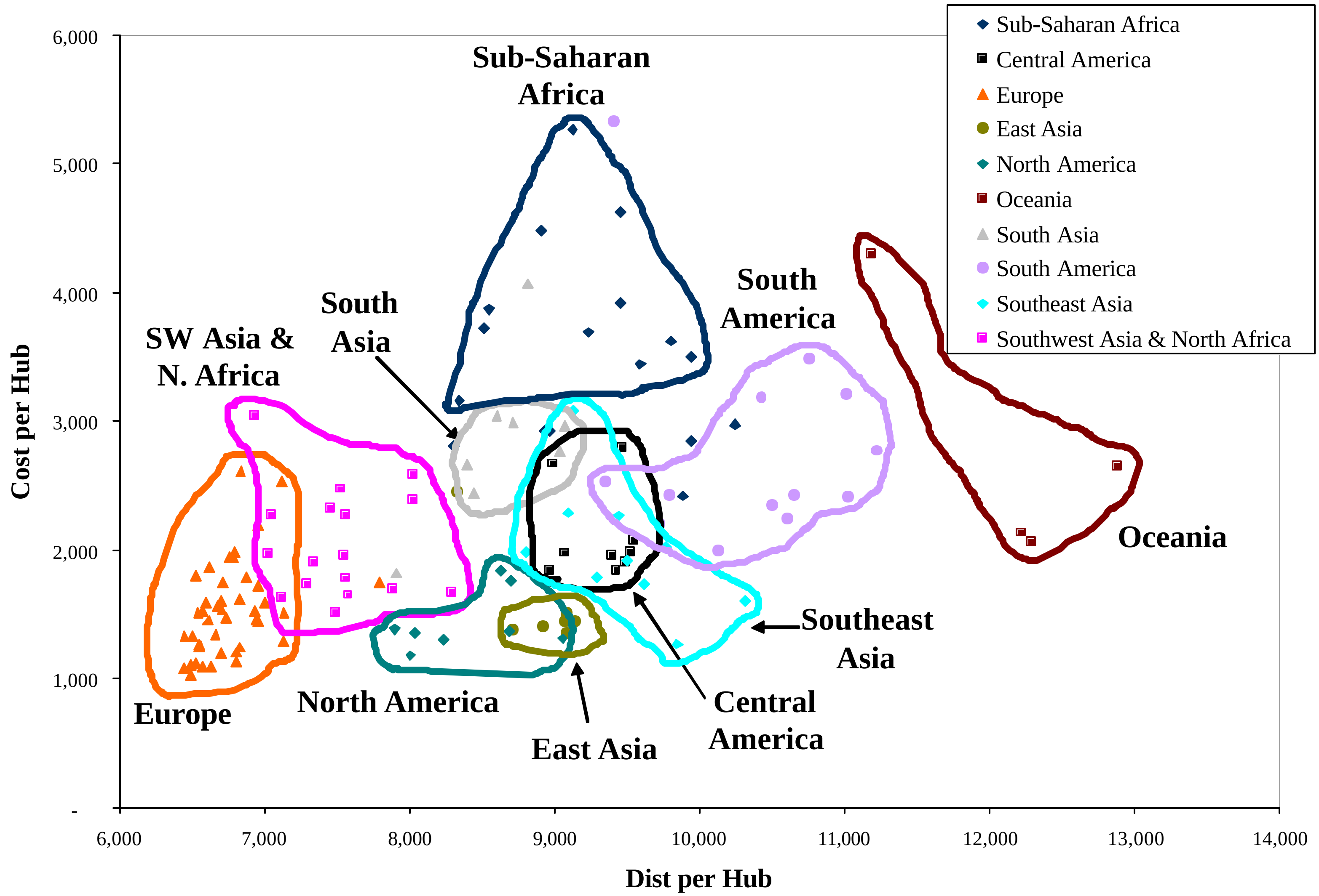


Figure 8, Time per Hub and Distance per Hub

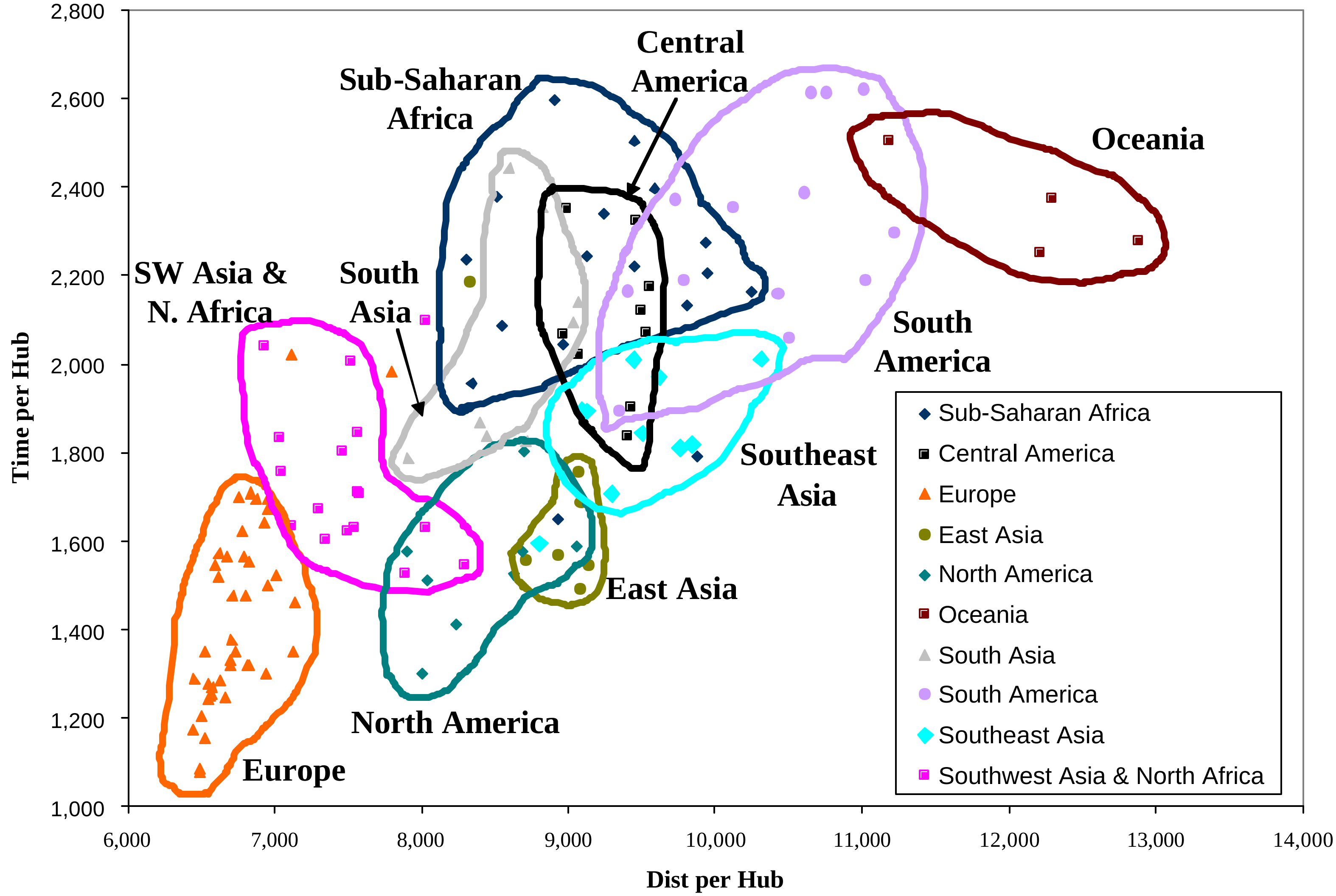
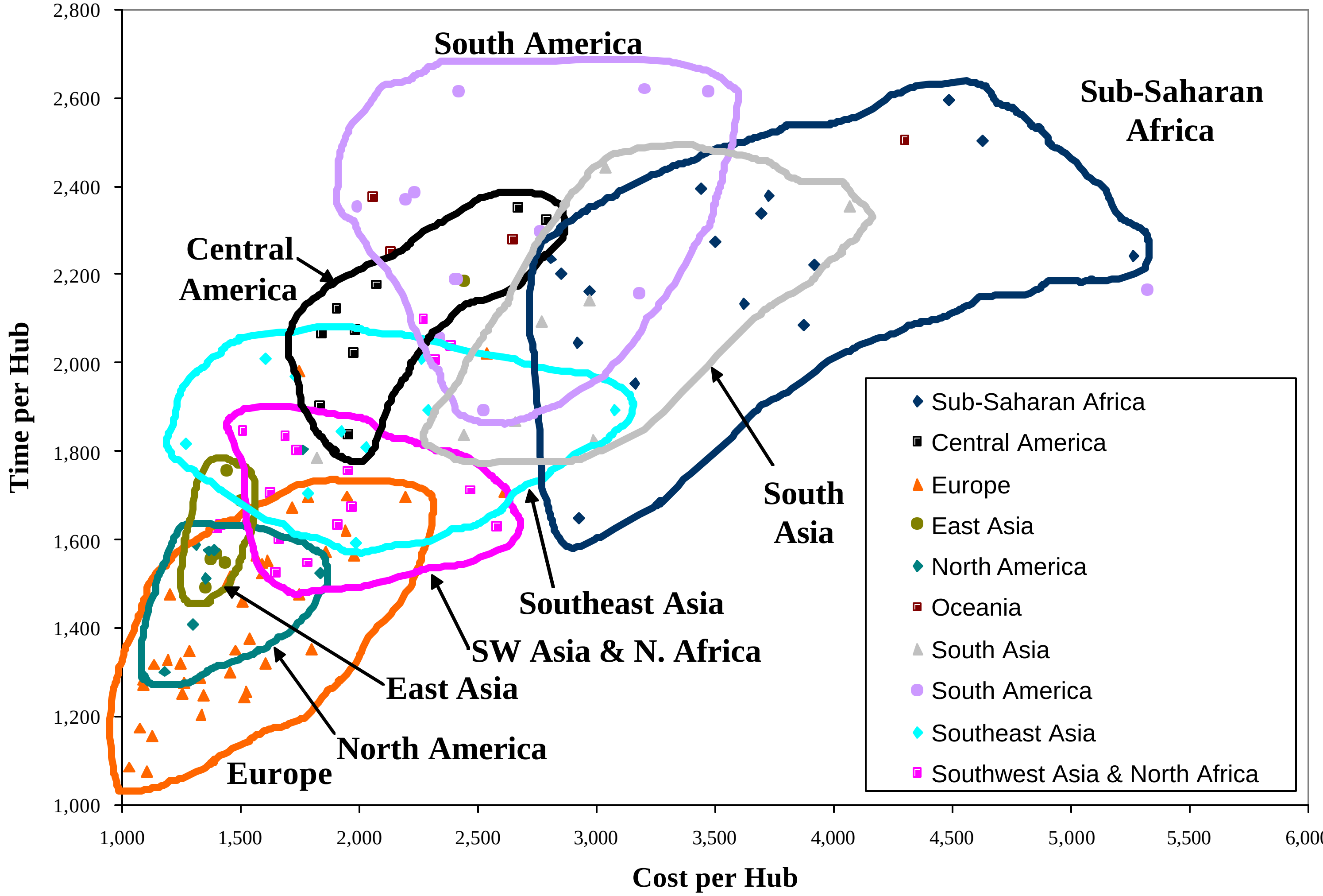


Figure 9, Time per Hub and Cost per Hub



Appendix A – Destination Cities

Addis Ababa, ETHIOPIA (ADD); Algiers, ALGERIA (ALG); Amman, JORDAN (AMM); Amsterdam, NETHERLANDS (AMS); Asunción, PARAGUAY (ASU); Athens, GREECE (ATH); Auckland, NEW ZEALAND (AKL); Baku, AZERBAIJAN (BAK); Bamako, MALI (BKO); Bangalore, INDIA (BLR); Bangkok, THAILAND (BKK); Barcelona, SPAIN (BCN); Beijing, CHINA (PEK); Beirut, LEBANON (BEY); Belgrade, YUGOSLAVIA (BEG); Berlin, GERMANY (BER); Birmingham, UNITED KINGDOM (BHX); Bogotá, COLOMBIA (BOG); Brussels, BELGIUM (BRU); Bucharest, ROMANIA (OTP); Budapest, HUNGARY (BUD); Buenos Aires, ARGENTINA (EZE); Cairo, EGYPT (CAI); Calcutta, INDIA (CCU); Cape Town, SOUTH AFRICA (CPT); Caracas, VENEZUELA (CCS); Casablanca, MOROCCO (CMN); Chicago, UNITED STATES OF AMERICA (CHI); Conakry, GUINEA (CKY); Copenhagen, DENMARK (CPH); Dakar, SENEGAL (DKR); Damascus, SYRIAN ARAB REPUBLIC (DAM); Dar Es Salam, UNITED REPUBLIC OF TANZANIA (DAR); Delhi, INDIA (DEL); Dhaka, BANGLADESH (DAC); Douglas (IOM) (IOM); Dublin, IRELAND (DUB); Gaborone, Botswana (GBE); Grand Cayman, Cayman Islands (GCM); Guadalajara, MEXICO (GDL); Guatemala City, GUATEMALA (GUA); Hanoi, VIET NAM (HAN); Harare, ZIMBABWE (HRE); Helsinki, FINLAND (HEL); Ho Chi Minh City, VIET NAM (SGN); Hong Kong, CHINA (HKG); Istanbul, TURKEY (IST); Jakarta, INDONESIA (CGK); Jidda, SAUDI ARABIA (JED); Johannesburg, SOUTH AFRICA (JNB); Karachi, PAKISTAN (KHI); Kathmandu, Nepal (KTM); Katowice, POLAND (KTW); Kiev, UKRAINE (KBP); Kigali, Rwanda (KGL); Kinshasa, DEM# REPUBLIC OF THE CONGO (FIH); Kuala Lumpur, MALAYSIA (KUL); Kuwait City, KUWAIT (KWI); La Paz, BOLIVIA (LPB); Lilongwe, Malawi (LLW); Lima, PERU (LIM); Lisbon, PORTUGAL (LIS); London, UNITED KINGDOM (LON); Los Angeles, UNITED STATES OF AMERICA (LAX); Luanda, ANGOLA (LAD); Lusaka, ZAMBIA (LUN); Madras, INDIA (MAA); Madrid, SPAIN (MAD); Managua, NICARAGUA (MGA); Manchester, UNITED KINGDOM (MAN); Manzini, Swaziland (MTS); Maputo, MOZAMBIQUE (MPM); Marseille, FRANCE (MRS); Medellín, COLOMBIA (MDE); Melbourne, AUSTRALIA (MEL); Metro Manila, PHILIPPINES (MNL); Mexico City, MEXICO (MEX); Miami-Hialeah, UNITED STATES OF AMERICA (MIA); Milan, ITALY (BGY); Minsk, BELARUS (MSQ); Montevideo, URUGUAY (MVD); Montréal, CANADA (YMQ); Moscow, RUSSIAN FEDERATION (MOW); Mumbai (Bombay), INDIA (BOM); Munich, GERMANY (MUC); Muscat, Oman (MCT); Nairobi, KENYA (NBO); Nassau, Bahamas - International (NAS); New York, UNITED STATES OF AMERICA (NYC); Nizhni Novgorod, RUSSIAN FEDERATION (GOJ); Novosibirsk, RUSSIAN FEDERATION (OVB); Osaka, JAPAN (OSA); Oslo, NORWAY (TRF); Paramaribo, Suriname - Zanderij Intl (PBM); Paris, FRANCE (PAR); Phnom Penh, CAMBODIA (PNH); Port Moresby, Papua New Guinea (POM); Port-au-Prince, HAITI (PAP); Prague, CZECH REPUBLIC (PRG); Quito, ECUADOR (UIO); Rabat, MOROCCO (RBA); Reykjavik, Iceland (KEF); Riga, LATVIA (RIX); Rio de Janeiro, BRAZIL (GIG); Riyadh, SAUDI ARABIA (RUH); Rome, ITALY (ROM); Saint Petersburg, RUSSIAN FEDERATION (LED); San Salvador, EL SALVADOR (SAL); Sana'a, YEMEN (SAH); Santiago, CHILE (SCL); Santo Domingo, DOMINICAN REPUBLIC (SDQ); São Paulo, BRAZIL (GRU); Seoul, REPUBLIC OF KOREA (SEL); Shanghai, CHINA (PVG); Singapore, SINGAPORE (SIN); Sofia, BULGARIA (SOF); Stockholm, SWEDEN (STO); Stuttgart, GERMANY (STR); Sydney, AUSTRALIA (SYD); Tallinn, Estonia (TLL); Tashkent, UZBEKISTAN (TAS); Tbilisi, GEORGIA (TBS); Tegucigalpa, HONDURAS (TGU); Tel Aviv-Jaffa, ISRAEL (TLV); Tirana, Albania (TIA);

Tokyo, JAPAN (TYO); Toronto, CANADA (YYZ); Tunis, TUNISIA (TUN); Ulan Bator, MONGOLIA (ULN); Vancouver, CANADA (YVR); Vienna, AUSTRIA (VIE); Vilnius, Lithuania (VNO); Warsaw, POLAND (WAW); Yangon, MYANMAR (RGN); Yerevan, ARMENIA (EVN); Zagreb, CROATIA (ZAG); Zürich, SWITZERLAND (ZRH);

PHYSICAL DISTANCE PER HUB

Cities with the smallest average distance

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Amsterdam, NETHERLANDS	AMS	6,447	1,076	1,174	0.167	0.182
2	Brussels, BELGIUM	BRU	6,451	1,326	1,289	0.206	0.200
3	London, UNITED KINGDOM	LON	6,491	1,106	1,077	0.170	0.166
4	Paris, FRANCE	PAR	6,492	1,031	1,086	0.159	0.167
5	Stuttgart, GERMANY	STR	6,503	1,333	1,204	0.205	0.185
6	Zürich, SWITZERLAND	ZRH	6,525	1,125	1,156	0.172	0.177
7	Birmingham, UNITED KINGDOM	BHX	6,528	1,799	1,351	0.256	0.193
8	Manchester, UNITED KINGDOM	MAN	6,545	1,514	1,245	0.231	0.190
9	Berlin, GERMANY	BER	6,552	1,261	1,278	0.192	0.195
10	Munich, GERMANY	MUC	6,556	1,252	1,251	0.191	0.191
11	Copenhagen, DENMARK	CPH	6,572	1,527	1,256	0.232	0.191
12	Prague, CZECH REPUBLIC	PRG	6,579	1,092	1,271	0.166	0.193
13	Douglas (IOM)	IOM	6,596	1,592	1,547	0.241	0.235
14	Milan, ITALY	BGY	6,615	1,452	1,519	0.219	0.230
15	Oslo, NORWAY	TRF	6,624	1,859	1,572	0.281	0.237
16	Dublin, IRELAND	DUB	6,628	1,092	1,284	0.165	0.194
17	Vienna, AUSTRIA	VIE	6,663	1,344	1,249	0.202	0.187
18	Katowice, POLAND	KTW	6,678	1,564	1,566	0.234	0.234
19	Stockholm, SWEDEN	STO	6,700	1,607	1,321	0.240	0.197
20	Warsaw, POLAND	WAW	6,703	1,192	1,329	0.178	0.198

Cities with the greatest average distance

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Auckland, NEW ZEALAND	AKL	12,880	2,648	2,277	0.206	0.177
2	Melbourne, AUSTRALIA	MEL	12,290	2,060	2,373	0.168	0.193
3	Sydney, AUSTRALIA	SYD	12,217	2,134	2,251	0.175	0.184
4	Santiago, CHILE	SCL	11,225	2,768	2,296	0.243	0.202
5	Port Moresby, Papua New Guinea	POM	11,183	4,302	2,503	0.393	0.229
6	Buenos Aires, ARGENTINA	EZE	11,031	2,404	2,186	0.214	0.194
7	Montevideo, URUGUAY	MVD	11,013	3,204	2,618	0.285	0.233
8	Asunción, PARAGUAY	ASU	10,765	3,475	2,611	0.318	0.239
9	La Paz, BOLIVIA	LPB	10,661	2,421	2,611	0.226	0.243
10	Lima, PERU	LIM	10,615	2,236	2,385	0.211	0.225
11	São Paulo, BRAZIL	GRU	10,510	2,337	2,057	0.222	0.196
12	Rio de Janeiro, BRAZIL	GIG	10,432	3,181	2,156	0.298	0.202
13	Jakarta, INDONESIA	CGK	10,313	1,603	2,011	0.161	0.202
14	Cape Town, SOUTH AFRICA	CPT	10,246	2,970	2,162	0.290	0.211
15	Quito, ECUADOR	UIO	10,129	1,993	2,351	0.197	0.232
16	Maputo, MOZAMBIQUE	MPM	9,946	2,851	2,203	0.283	0.219
17	Manzini, Swaziland	MTS	9,939	3,497	2,274	0.348	0.226
18	Johannesburg, SOUTH AFRICA	JNB	9,880	2,420	1,791	0.245	0.181
19	Singapore, SINGAPORE	SIN	9,845	1,269	1,817	0.129	0.185
20	Gaborone, Botswana	GBE	9,807	3,623	2,133	0.369	0.217

COST DISTANCE PER HUB

Cities with the lowest average cost

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Paris, FRANCE	PAR	6,492	1,031	1,086	0.159	0.167
2	Amsterdam, NETHERLANDS	AMS	6,447	1,076	1,174	0.167	0.182
3	Prague, CZECH REPUBLIC	PRG	6,579	1,092	1,271	0.166	0.193
4	Dublin, IRELAND	DUB	6,628	1,092	1,284	0.165	0.194
5	London, UNITED KINGDOM	LON	6,491	1,106	1,077	0.170	0.166
6	Zürich, SWITZERLAND	ZRH	6,525	1,125	1,156	0.172	0.177
7	Rome, ITALY	ROM	6,811	1,134	1,319	0.166	0.194
8	New York, UNITED STATES OF A	NYC	8,008	1,180	1,302	0.147	0.163
9	Warsaw, POLAND	WAW	6,703	1,192	1,329	0.178	0.198
10	Helsinki, FINLAND	HEL	6,805	1,204	1,477	0.177	0.217
11	Barcelona, SPAIN	BCN	6,831	1,244	1,319	0.182	0.193
12	Munich, GERMANY	MUC	6,556	1,252	1,251	0.191	0.191
13	Berlin, GERMANY	BER	6,552	1,261	1,278	0.192	0.195
14	Singapore, SINGAPORE	SIN	9,845	1,269	1,817	0.129	0.185
15	Lisbon, PORTUGAL	LIS	7,128	1,286	1,349	0.180	0.189
16	Chicago, UNITED STATES OF AM	CHI	8,239	1,300	1,411	0.158	0.171
17	Los Angeles, UNITED STATES OF	LAX	9,054	1,311	1,589	0.145	0.176
18	Brussels, BELGIUM	BRU	6,451	1,326	1,289	0.206	0.200
19	Stuttgart, GERMANY	STR	6,503	1,333	1,204	0.205	0.185
20	Vienna, AUSTRIA	VIE	6,663	1,344	1,249	0.202	0.187

Cities with the highest average cost

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Paramaribo, Suriname - Zanderij In	PBM	9,408	5,324	2,163	0.497	0.202
2	Luanda, ANGOLA	LAD	9,125	5,263	2,242	0.561	0.239
3	Lilongwe, Malawi	LLW	9,453	4,627	2,502	0.492	0.266
4	Kigali, Rwanda	KGL	8,908	4,483	2,595	0.531	0.307
5	Port Moresby, Papua New Guinea	POM	11,183	4,302	2,503	0.393	0.229
6	Calcutta, INDIA	CCU	8,820	4,069	2,354	0.461	0.267
7	Lusaka, ZAMBIA	LUN	9,454	3,918	2,221	0.409	0.232
8	Addis Ababa, ETHIOPIA	ADD	8,549	3,872	2,086	0.453	0.244
9	Conakry, GUINEA	CKY	8,514	3,727	2,378	0.420	0.268
10	Dar Es Salam, UNITED REPUBLIC	DAR	9,238	3,692	2,339	0.400	0.253
11	Gaborone, Botswana	GBE	9,807	3,623	2,133	0.369	0.217
12	Manzini, Swaziland	MTS	9,939	3,497	2,274	0.348	0.226
13	Asunción, PARAGUAY	ASU	10,765	3,475	2,611	0.318	0.239
14	Harare, ZIMBABWE	HRE	9,589	3,443	2,395	0.359	0.250
15	Montevideo, URUGUAY	MVD	11,013	3,204	2,618	0.285	0.233
16	Rio de Janeiro, BRAZIL	GIG	10,432	3,181	2,156	0.298	0.202
17	Dakar, SENEGAL	DKR	8,346	3,160	1,954	0.374	0.231
18	Yangon, MYANMAR	RGN	9,129	3,077	1,893	0.361	0.222
19	Sana'a, YEMEN	SAH	8,361	3,042	2,039	0.364	0.244
20	Kathmandu, Nepal	KTM	8,601	3,036	2,443	0.353	0.284

TIME DISTANCE PER HUB

Cities with the lowest average time

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	London, UNITED KINGDOM	LON	6,491	1,106	1,077	0.170	0.166
2	Paris, FRANCE	PAR	6,492	1,031	1,086	0.159	0.167
3	Zürich, SWITZERLAND	ZRH	6,525	1,125	1,156	0.172	0.177
4	Amsterdam, NETHERLANDS	AMS	6,447	1,076	1,174	0.167	0.182
5	Stuttgart, GERMANY	STR	6,503	1,333	1,204	0.205	0.185
6	Manchester, UNITED KINGDOM	MAN	6,545	1,514	1,245	0.231	0.190
7	Vienna, AUSTRIA	VIE	6,663	1,344	1,249	0.202	0.187
8	Munich, GERMANY	MUC	6,556	1,252	1,251	0.191	0.191
9	Copenhagen, DENMARK	CPH	6,572	1,527	1,256	0.232	0.191
10	Prague, CZECH REPUBLIC	PRG	6,579	1,092	1,271	0.166	0.193
11	Berlin, GERMANY	BER	6,552	1,261	1,278	0.192	0.195
12	Dublin, IRELAND	DUB	6,628	1,092	1,284	0.165	0.194
13	Brussels, BELGIUM	BRU	6,451	1,326	1,289	0.206	0.200
14	Madrid, SPAIN	MAD	6,946	1,455	1,302	0.209	0.187
15	New York, UNITED STATES OF A	NYC	8,008	1,180	1,302	0.147	0.163
16	Rome, ITALY	ROM	6,811	1,134	1,319	0.166	0.194
17	Barcelona, SPAIN	BCN	6,831	1,244	1,319	0.182	0.193
18	Stockholm, SWEDEN	STO	6,700	1,607	1,321	0.240	0.197
19	Warsaw, POLAND	WAW	6,703	1,192	1,329	0.178	0.198
20	Lisbon, PORTUGAL	LIS	7,128	1,286	1,349	0.180	0.189

Cities with the highest average time

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Montevideo, URUGUAY	MVD	11,013	3,204	2,618	0.285	0.233
2	Asunción, PARAGUAY	ASU	10,765	3,475	2,611	0.318	0.239
3	La Paz, BOLIVIA	LPB	10,661	2,421	2,611	0.226	0.243
4	Kigali, Rwanda	KGL	8,908	4,483	2,595	0.531	0.307
5	Port Moresby, Papua New Guinea	POM	11,183	4,302	2,503	0.393	0.229
6	Lilongwe, Malawi	LLW	9,453	4,627	2,502	0.492	0.266
7	Kathmandu, Nepal	KTM	8,601	3,036	2,443	0.353	0.284
8	Harare, ZIMBABWE	HRE	9,589	3,443	2,395	0.359	0.250
9	Lima, PERU	LIM	10,615	2,236	2,385	0.211	0.225
10	Conakry, GUINEA	CKY	8,514	3,727	2,378	0.420	0.268
11	Melbourne, AUSTRALIA	MEL	12,290	2,060	2,373	0.168	0.193
12	Medellín, COLOMBIA	MDE	9,732	2,196	2,370	0.229	0.247
13	Calcutta, INDIA	CCU	8,820	4,069	2,354	0.461	0.267
14	Quito, ECUADOR	UIO	10,129	1,993	2,351	0.197	0.232
15	Port-au-Prince, HAITI	PAP	8,992	2,670	2,350	0.291	0.256
16	Dar Es Salam, UNITED REPUBLIC	DAR	9,238	3,692	2,339	0.400	0.253
17	Tegucigalpa, HONDURAS	TGU	9,464	2,793	2,323	0.317	0.264
18	Santiago, CHILE	SCL	11,225	2,768	2,296	0.243	0.202
19	Auckland, NEW ZEALAND	AKL	12,880	2,648	2,277	0.206	0.177
20	Manzini, Swaziland	MTS	9,939	3,497	2,274	0.348	0.226

COST DISTANCE PER HUB PER PHYSICAL DISTANCE

Cities with the lowest average cost per kilometer

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Singapore, SINGAPORE	SIN	9,845	1,269	1,817	0.129	0.185
2	Los Angeles, UNITED STATES OF	LAX	9,054	1,311	1,589	0.145	0.176
3	New York, UNITED STATES OF A	NYC	8,008	1,180	1,302	0.147	0.163
4	Tokyo, JAPAN	TYO	9,086	1,353	1,490	0.149	0.164
5	Shanghai, CHINA	PVG	9,073	1,442	1,754	0.149	0.181
6	Seoul, REPUBLIC OF KOREA	SEL	8,932	1,401	1,566	0.157	0.175
7	Miami-Hialeah, UNITED STATES C	MIA	8,690	1,365	1,576	0.157	0.181
8	Hong Kong, CHINA	HKG	9,150	1,438	1,546	0.157	0.169
9	Chicago, UNITED STATES OF AM	CHI	8,239	1,300	1,411	0.158	0.171
10	Beijing, CHINA	PEK	8,719	1,379	1,555	0.158	0.178
11	Paris, FRANCE	PAR	6,492	1,031	1,086	0.159	0.167
12	Jakarta, INDONESIA	CGK	10,313	1,603	2,011	0.161	0.202
13	Dublin, IRELAND	DUB	6,628	1,092	1,284	0.165	0.194
14	Osaka, JAPAN	OSA	9,091	1,508	1,687	0.166	0.186
15	Prague, CZECH REPUBLIC	PRG	6,579	1,092	1,271	0.166	0.193
16	Rome, ITALY	ROM	6,811	1,134	1,319	0.166	0.194
17	Amsterdam, NETHERLANDS	AMS	6,447	1,076	1,174	0.167	0.182
18	Melbourne, AUSTRALIA	MEL	12,290	2,060	2,373	0.168	0.193
19	Toronto, CANADA	YYZ	8,036	1,355	1,513	0.169	0.188
20	London, UNITED KINGDOM	LON	6,491	1,106	1,077	0.170	0.166

Cities with the highest average cost per kilometer

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Luanda, ANGOLA	LAD	9,125	5,263	2,242	0.561	0.239
2	Kigali, Rwanda	KGL	8,908	4,483	2,595	0.531	0.307
3	Paramaribo, Suriname - Zanderij In	PBM	9,408	5,324	2,163	0.497	0.202
4	Lilongwe, Malawi	LLW	9,453	4,627	2,502	0.492	0.266
5	Calcutta, INDIA	CCU	8,820	4,069	2,354	0.461	0.267
6	Addis Ababa, ETHIOPIA	ADD	8,549	3,872	2,086	0.453	0.244
7	Conakry, GUINEA	CKY	8,514	3,727	2,378	0.420	0.268
8	Lusaka, ZAMBIA	LUN	9,454	3,918	2,221	0.409	0.232
9	Kinshasa, DEM# REPUBLIC OF TI	FIH	8,929	2,925	1,649	0.405	0.228
10	Dar Es Salam, UNITED REPUBLIC	DAR	9,238	3,692	2,339	0.400	0.253
11	Port Moresby, Papua New Guinea	POM	11,183	4,302	2,503	0.393	0.229
12	Nizhni Novgorod, RUSSIAN FEDEI	GOJ	7,120	2,536	2,022	0.391	0.312
13	Minsk, BELARUS	MSQ	6,837	2,613	1,709	0.382	0.250
14	Dakar, SENEGAL	DKR	8,346	3,160	1,954	0.374	0.231
15	Gaborone, Botswana	GBE	9,807	3,623	2,133	0.369	0.217
16	Sana'a, YEMEN	SAH	8,361	3,042	2,039	0.364	0.244
17	Yangon, MYANMAR	RGN	9,129	3,077	1,893	0.361	0.222
18	Tbilisi, GEORGIA	TBS	7,426	2,273	1,711	0.360	0.271
19	Harare, ZIMBABWE	HRE	9,589	3,443	2,395	0.359	0.250
20	Tirana, Albania	TIA	6,935	2,388	1,631	0.355	0.242

TIME DISTANCE PER HUB PER PHYSICAL DISTANCE

Cities with the lowest average time per kilometer

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	New York, UNITED STATES OF A	NYC	8,008	1,180	1,302	0.147	0.163
2	Tokyo, JAPAN	TYO	9,086	1,353	1,490	0.149	0.164
3	London, UNITED KINGDOM	LON	6,491	1,106	1,077	0.170	0.166
4	Paris, FRANCE	PAR	6,492	1,031	1,086	0.159	0.167
5	Hong Kong, CHINA	HKG	9,150	1,438	1,546	0.157	0.169
6	Chicago, UNITED STATES OF AM	CHI	8,239	1,300	1,411	0.158	0.171
7	Seoul, REPUBLIC OF KOREA	SEL	8,932	1,401	1,566	0.157	0.175
8	Los Angeles, UNITED STATES OF	LAX	9,054	1,311	1,589	0.145	0.176
9	Vancouver, CANADA	YVR	8,628	1,835	1,525	0.213	0.177
10	Auckland, NEW ZEALAND	AKL	12,880	2,648	2,277	0.206	0.177
11	Zürich, SWITZERLAND	ZRH	6,525	1,125	1,156	0.172	0.177
12	Beijing, CHINA	PEK	8,719	1,379	1,555	0.158	0.178
13	Johannesburg, SOUTH AFRICA	JNB	9,880	2,420	1,791	0.245	0.181
14	Miami-Hialeah, UNITED STATES (	MIA	8,690	1,365	1,576	0.157	0.181
15	Shanghai, CHINA	PVG	9,073	1,442	1,754	0.149	0.181
16	Amsterdam, NETHERLANDS	AMS	6,447	1,076	1,174	0.167	0.182
17	Bangkok, THAILAND	BKK	9,297	1,784	1,707	0.192	0.184
18	Sydney, AUSTRALIA	SYD	12,217	2,134	2,251	0.175	0.184
19	Singapore, SINGAPORE	SIN	9,845	1,269	1,817	0.129	0.185
20	Stuttgart, GERMANY	STR	6,503	1,333	1,204	0.205	0.185

Cities with the highest average time per kilometer

	City-Country	Code	Dist per Hub	Cost per Hub	Time per Hub	Cost per Hub per KM	Time per Hub per KM
1	Nizhni Novgorod, RUSSIAN FEDEI	GOJ	7,120	2,536	2,022	0.391	0.312
2	Kigali, Rwanda	KGL	8,908	4,483	2,595	0.531	0.307
3	Novosibirsk, RUSSIAN FEDERATI	OVB	7,798	1,748	1,982	0.256	0.290
4	Kathmandu, Nepal	KTM	8,601	3,036	2,443	0.353	0.284
5	Tashkent, UZBEKISTAN	TAS	7,908	1,820	1,786	0.277	0.272
6	Ulan Bator, MONGOLIA	ULN	8,338	2,445	2,184	0.304	0.271
7	Tbilisi, GEORGIA	TBS	7,426	2,273	1,711	0.360	0.271
8	Yerevan, ARMENIA	EVN	7,458	1,737	1,674	0.281	0.270
9	Conakry, GUINEA	CKY	8,514	3,727	2,378	0.420	0.268
10	Calcutta, INDIA	CCU	8,820	4,069	2,354	0.461	0.267
11	Lilongwe, Malawi	LLW	9,453	4,627	2,502	0.492	0.266
12	Tegucigalpa, HONDURAS	TGU	9,464	2,793	2,323	0.317	0.264
13	Bamako, MALI	BKO	8,304	2,808	2,236	0.327	0.261
14	Baku, AZERBAIJAN	BAK	7,562	2,472	2,005	0.320	0.260
15	Port-au-Prince, HAITI	PAP	8,992	2,670	2,350	0.291	0.256
16	Jidda, SAUDI ARABIA	JED	8,025	2,581	2,098	0.314	0.255
17	Dar Es Salam, UNITED REPUBLIC	DAR	9,238	3,692	2,339	0.400	0.253
18	Belgrade, YUGOSLAVIA	BEG	6,829	1,616	1,554	0.263	0.253
19	Riga, LATVIA	RIX	6,761	1,946	1,699	0.288	0.251
20	Rabat, MOROCCO	RBA	7,299	1,972	1,833	0.270	0.251