The world urban system from a multifunctional and multiscalar perspective: a gridded cartogram as a model of spatial representation

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ABSTRACT
This paper aims to show the current spatial organization that characterizes world urban system from a multifunctional and multiscalar perspective. Methodology, the assessment of the urban system was economic in nature traditionally, taking into consideration some of the most important events, such as transnational corporations, financial flows and advanced services, among others. However, it is now more common to see those approaches that interpret globalization from a more holistic perspective, where many evidences have a place: on the one hand, cultural services because of the development and consolidation of the ‘cultural economy’, ‘consumption society’ and leisure time; on the other hand, air transportation as statistic parameter of global air flows in the presence of the new mobilities paradigm. In addition to these functional approaches, the result of the analysis seeks to describe a world urban system from a scalar perspective. It means that the goal is not only to determine the major cities, but those other ones that undergo parallel processes of globalization with respect to the global cities, characterized by their more functional specialization. World urban system is mapped using a gridded cartogram which shows its unbalanced and hierarchical organization.

1. Introduction

The study of the territorial processes from a geographic perspective on a global scale has had a great impact in the academic world (Alderson & Beckfield, 2004; Taylor, Derudder, Hoyler, & Ni, 2013; among others). At present, the study of global urban systems is still a complex phenomenon and therefore one of the great challenges of geography as a consequence of the many changes that have occurred in the context of globalization: transport revolution and tertiary society, among others.

The first one (transport revolution) has not only contributed to increase the flows quantitatively, but also the speed and scope with which they are carried out, leading to a reduction of distances and a contraction of space, which has been called ‘Time-space compression’ (Harvey, 1989) or ‘plasticity of space’ (Relp, 1976), among others.

Regarding the second one (tertiary society), the process of cumulative growth that agglomerations had experienced since the Industrial Revolution was overshadowed not only by the processes of suburbanization and metropolitanization (thanks to advances in communications), but mainly by a concentration of activities related to the tertiary sector which is highly specialized, and which in turn focuses on the heart of the world’s major cities (Sassen, 1991). We are witnessing, therefore, a decline in industrial centres as a result of deindustrialization and, at the same time, the rise of city of services with a concentration in financial, banking and high technology industries whose production is dematerialized through information, knowledge and services.5

These changes favoured the academic debate on the so-called global cities and other key concepts of geography such as city networks and urban hierarchies, among others. Since the pioneering approaches Geddes (1915) until today, there have been numerous proposals that attempt not only to define what global city is meant, but also their positioning in a hypothetical world urban system.

The fundamental objective of this work is to identify the organization of a complex urban system at a global scale under two basic principles of spatial organization, such as the functional analysis of urban nodes and the scale perspective; both criteria allow a real knowledge of the archipelago of cities, according to the development of cultural services and the mobility of global order.

Regarding the multifunctional organization of cities, we consider that the assessment of the world system of cities was economic in nature traditionally, taking into consideration some of the most important events, such as transnational corporations, financial flows and advanced services. Many studies have highlighted...
repeatedly the same cities from this economic perspective (Castells, 1996; Friedmann, 1986; Hymer, 1972; Reed, 1981; Sassen, 1991; Taylor, 2004 among others). However, we believe that besides the economic perspective, there are many vectors that complement the description and help us to understand the world system of cities from a perspective much more complex and adapted to current realities. Among these vectors, culture predominates (Pratt, 2011; Scott, 2000).

The study of culture has had little impact on the concept of global city until recently, despite the growing reputation of creative and cultural activities in the economy (Howkins, 2007). In this paper and, from a methodological point of view, the concept of culture is not understood in its anthropological or social version but in that which derives from its role as cultural industries. In this approach, a number of cultural indicators have been used and coined Cultural Components of Globalized Capitalism, whose identification in most cases has been proposed by international institutions dedicated to culture, mainly by UNESCO (2009). These components are close to the cultural dimension of cities from a measurable perspective (supply and demand) to assess the number of users and the supply of resources (heritage, music, tourism, exhibitions, museums, cultural industries, sports or events, entertainment and recreation, etc.).

These activities now play a significant role in urban planning, not only from a material point of view (attraction of foreign currencies, investments and tourists), but also by their power of persuasion, the image they project, and the symbolic/intangible values by which they are recognized in the current ‘cultural economy’ and ‘mass consumption society’ (Bauman, 2013; Ritzer, 2002; Toffler, 1980).

Although the analysis of cultural services confers revealing results, they are considered insufficient for a proper understanding of world urban system. Therefore, the so-called Synthetic Index of Air Transportation is proposed as an indicator of territorial organization on a global scale to better understand the complexity of the urban phenomenon. Although it does not define the worldwide ranking of cities, has great interest for one reason: in addition to synthesizing the economic and cultural functions, it has highlighted the possible existence of others that we do not know or we can perceive wrongly (centrality, political function or religious role, among others) (Córdoba & Gago, 2010).

Regarding the scalar perspective, researches on urban issues should not focus exclusively on the most representative cities of the world urban hierarchy, but also in the study of flows and territorial connections from other cities using a multiscale perspective. Following the idea of Marcuse and Kempen (2000) about that globalization is a process that manifests itself in different ways and intensities; it is intended not only to identify those global cities, almost always multifunctional in nature, but also to evaluate those ones where certain uniqueneses determine broad areas of influence, though much more specialized. These cities, although a little far away from the concept of the global city accepted in the academic world, also contribute to the organization of the territory.

The result of the analysis is intended to describe a map of the world urban system where besides the traditionally mapped cities, others are seen because of their functional specialization which goes beyond the economic approach.

2. Methodology

Broadly speaking, three indices have been used to evaluate cities in relation to their ranks and functions (multifunctional cities vs. specialized cities). These three indices include different approaches: economic, cultural and air transport:

(1) Synthetic Index of GaWC, SI-GaWC (economic approach): This ranking is made by the GaWC research group at Loughborough University, UK. It is based on what is called ‘interlocking model’ (Taylor, Walker, Catalano, & Hoyler, 2002a). Interlocking model means cities are assessed in terms of their advanced producer flows since they are considered one of the most important vectors of the economic globalization (Sassen, 1991; Taylor, 2004). This hierarchy is widely recognized and cited in the academic world (Bassens, 2012; Sánchez Moral, 2008 among others). The results have been taken directly.

(2) Synthetic Index of Cultural Components, SICC (cultural approach). This one has been fully carried out in this research. For its elaboration, an open perspective (without preselected cities) that combines eight major cultural and quantifiable dimensions, suggested by UNESCO (2009) has been used (Table 1). All indicators (collected mostly in 2012–2013), are subject to a statistical analysis and a normalization process, before assigning the corresponding discriminant weights to obtain a synthetic index that reflects an urban hierarchy in relation to cultural services that urban nodes include.

(3) Synthetic Index of Air Transport, SIAT (Air transport approach): This one has also been carried out in this research. Once airports (or airport systems, in case of there several airports in a same city) whose international air traffic is over one million passengers (ACI, 2011) are selected, two fundamental statistical criteria will be used: international air connections and frequencies (OAG-International, 2011). Both are weighted according to the distance between the emitting region to which the city and the receiving area of the city of destination belongs. Both parameters will
allow us to obtain an urban hierarchy in relation to the role of international air activity.

The values of the three indices are not only grouped by world regions to offer knowledge to a continental/regional scale, but also hierarchically ordered from the largest to smallest. Due to the fact that the SIGaWC and SIAT data are relational (connectivity index of advanced services and air connections), and the SICC data are discrete (number of activities/cultural services), it is decided to convert the three indexes into ordinal values to carry out integrated analysis, removing the mismatch between data. Because the three indices are made up of a different number of cities, they have been dimensioned in the top 150 cities to have the same extension.

Once the rankings are finished, the next step is to make the crossed analysis of the three available hierarchical indices. A cluster analysis (k-means clustering) has been used to classify the sample of cities into

| Cultural domains | Theme | Indicator | Source | Units |
|------------------|-------|-----------|--------|-------|
| 1. Cultural and natural heritage | Heritage | World Heritage cities | Organization of World Heritage Cities (OWHC, 2012) | N° of cities |
| | Art | Museums | The Art Newspaper (2010) | N° of visits |
| |  | Art exhibitions | Average daily attendance |
| |  | N° of exhibitions |
| 2. Performance and celebration | International music concerts | Opera performance | Official websites of every artist | N° performances by Renee Fleming, Natalie Dessay, Anna Netrebko, Juan Diego Flórez, Plácido Domingo and Jonas Kaufmann (2008–2013) |
| |  | Pop concerts | Official websites of every artist | N° performances by Madonna, Jennifer López, Justin Bieber, Rihanna, Lady Gaga and Britney Spears (World tours, 2008–2012) |
| |  | Rock concerts | Official websites of every artist | N° performances by Eagles, ACDC, Aerosmith, Rolling Stones, Bruce Springsteen and Metallica (World tours, 2008–2012) |
| 3. Education and training | Education | Universities | ARWU Ranking (2011) | N° universities |
| |  | | QS Ranking (2011) | N° universities |
| |  | International students | Total valor |
| 4. Books and press | Press | News agencies | Silver (2011) | N° citations in Google News and Blogs |
| |  | Newspapers | 4 International Media & Newspaper (IMN, 2011) | Newspaper ranking |
| | | Books | World Publishing Livres | Sales (millions of euros) |
| | | Publishing | ‘Hebdo’ (WPPL, 2010) | N° of companies |
| | | Search engine | ‘Google’, Feb. 2012 | N° of results found |
| |  | N° of exhibitions | N° of exhibitions |
| 5. Audio-visual and Interactive media | Internet | Search engine | ‘YouTube’, Feb. 2012 | N° of results found |
| | Cinema | Film festivals | Database | N° of attendees |
| |  |  | ‘Film Festival World’ (2012) | N° of mass media |
| 6. Design and creative services | Fashion | Fashion capitals | Global Language Monitor (2011) | Indice Global Language Monitor |
| | Universal exhibitions | Fashion Week | Fashions (2011) | Fashion Week Cities |
| |  | Universal exhibitions | BIE (until 2015) | N° of universal exhibitions (since WWII) |
| |  | Bureau of International Expositions | |
| 7. Tourism | Tourism | International tourist arrivals | Euromonitor (2011) | N° of international tourists |
| | International congresses | International Congress and Convention Association (ICCA, 2010) | N° of attendees |
| |  | International Congress and Convention Association (ICCA, 2010) | N° of international events |
| 8. Sports and recreation | Sports | Olympic Games | Official website http://www.olympic.org/ | Olímpic Games host cities (since WWII) |
| |  | Soccer | Official website http://es.fifa.com/worldcup/index.html | N° of FIFA World Cup finals (since WWII) |
| | American football | Official website http://www.nfl.com/superbowl | N° of Super Bowl (final) |
| | Formula 1 | Official website http://www.formula1.com | N° of Grand Prix F1 Championship |
| | Grand Prix | IAAF Athletics World Championship | Official website http://www.iaaf.org/ | N° of finals |
| | ATP World Tour | The Sports Association (TEA, 2012) | Themed Entertainment Association (TEA, 2012) | N° of events (Grand Slam, Master 1000, Master 500 and Master 250) |
| | Tennis | Recreation | Forbes Magazine (2004) | The world best casinos |
| | Theme Parks | Businessweek Magazine (2012) | The world largest casinos |

Source: Own elaboration.
different groups with similar statistical behaviour. One difficulty in applying this technique is that it does not automatically determine the number of groups/clusters, but it requires a subsequent interpretation by the researcher in order to make the results as relevant as possible. This interpretation leads to a regrouping of the clusters based on the number of indices in which cities are represented and their ranks in those indices. From the scalar perspective (rank criteria), two big types of cities have been identified:

- **A Nodes** (Global functional nodes). These cities, especially the most important ones, have become key nodes of power (rather than states) in economic, geopolitical and symbolical terms, by concentrating all kinds of information, flows and goods of disparate nature. Two sub-types are differentiated:
  - o A1: Three indices whose average ranks are in the top 50.
  - o A2: Three indices whose average ranks in one or two indicators are below top 50.
- **B nodes** (Secondary specialized nodes). These cities have a more limited reach than A Nodes, and a very marked level of functional specialization which allows them to compete in the urban hierarchy and expand their areas of influence in many cases. Two sub-types are identified:
  - o B1: Noted ranks in three indices, although average ranks below A nodes. This fact gives a higher functional specialization.
  - o B2: Noted ranks in one or two indices (maximum functional specialization).

Additionally, the functional perspective allows the determining of the functional inclination or specialization of cities in the world urban system. This specialization might be cultural (when *Synthetic Index of Cultural Components* stands out), economic (when *GaWC Synthetic Index* highlights) or based on air transport (when *Synthetic Index of Air Transport* reaches a high position).

After interpreting the obtained groups, they are mapped using a gridded cartogram as a model of spatial representation. The displayed cities were selected because their statuses are over the 150 rank in, at least, one of the three indices. Each individual grid cell is labelling according to specific quantitative information which was mentioned previously: the number of indices in which cities are represented (functional dimension; colour of 3-letter code) and their ranks in those indices (scalar perspective; colour of grids). A synthetic treatment of data may be observed in Table 2.

This type of cartogram is used following a long tradition in GaWC publications, though it is not the only model of representation that members of the GaWC research group use in their researches (Kraetke, 2014; Taylor, Walker, & Beaverstock, 2002b, among others). The cartogram was selected for this paper because it is the only one that corrects the mapping saturation that follows by representing the links based on air transport. Since the space of flows is predominant today (Castells, 1996), it is considered suitable to add the two most important inter-regional air flows per world region because it is academically accepted that they reproduce largely the structure of other global flows (Gago, 2003). In this way, static data (ranks of indices) and relational data (international links based on air traffic) are combined in the same spatial representation.

### 3. Results

The world urban system described in the gridded cartogram (*Main Map*) corroborates the hypothesis according to which it is necessary to study world urban system under two basic principles of spatial organization: (i) the functional organization, which also has a place for other indicators beyond the economic ones and (ii) the scale perspective, where in...
addition to identifying global cities, research identifies other secondary ones (or globalizing, in terms of Markus and Kempen).

This double dynamic of insertion is identified in the proposed model with two types of cities: multifunctional global nodes (A nodes), widely identified in the scientific literature, and specialized secondary nodes (B nodes), less commonly considered in academic work. The results have shown the unbalanced, hierarchical and compartmentalized spatial organization that characterizes world urban archipelago, in concordance with the world-systems theory (Wallerstein, 1974).

On the one hand, the observed scene described the ‘Nortes’ (the Center), with a high diversification in terms of scalar levels and functional indicators, thanks to the large number of cities shown, leading to greater integration and cohesion of the respective regional subsystems. Europe and North America are the central regions of the world system. However, the Asian region is increasing its international power thanks to the Japanese nodes and recently with the rise of so-called emerging countries (China and India nodes) and others from Southeast Asia, which show the transfer of part of the economic and productive power to the East.

On the other hand, the ‘Sures’ (Periphery) should be noted, with a lower presence of nodes and hence smaller scale and functional diversity. In addition to the competitive strategies from periphery and semi-periphery cities, an increasingly important form of participation in the global circuits through tourism must be taken into account. Additionally, the air flows show the peripheral and dependent character of South regions on North regions.

4. Conclusions

- This paper outlines the proposed model used to map the world system of cities from a multifunctional and multiscalar perspective, beyond focusing on just global cities and economical parameters.
- Cultural services and air links have exhibited ‘other’ cities in the world urban system, which play an extraordinary role in globalization in spite of being omitted in most of the world urban rankings.
- The gridded cartogram shows the unbalanced, hierarchical and compartmentalized spatial organization that characterizes world urban system: a high diversification in terms of scalar levels and functional indicators in Center and a lower diversification in Periphery.
- A very brief interpretation to the inter-regional air links shows that the directionality of global flows is focused in the Center, while Periphery plays a dependent role (on North).
- The work reported here demonstrates the importance of cultural services and air transportation data to measure the world urban system and highlights the need to combine static and relational data as a mode of enhancing its complex knowledge.

Notes

1. It should be noted that this juxtaposition between tertiarisation of urban economies and des-industrialisation is currently more complex as reflected on the debates about the outsourcing of services activities or other forms of re-industrialization of cities (Hutton, 2009; Krätke, 2012).
2. In this way, the analysis focuses on those symbolic and intellectual creations which, after being subjected to an assembly-line production, become commercial goods and therefore, in commercialized cultural industries (Bauman, 2013).
3. Although implicitly economic biases are identified in the three indices, they are differentiated thematically to better understand the proposal approaches.
4. World regions considered in this investigation were taken from two official publications: United Nations (2006) and Word Bank (2012).
5. By unifying the three indices, it can be noted how some cities have no representation in a particular ranking. In these cases, they are assigned the 151 value; with this figure, we include those cities that are not present in the original index, or even including, are present but below the 150 rank; regardless of they are or not in the original index.
6. This functional inclination or specialization is determined by the difference of the ranks. If the difference is very marked, it is referred to as specialization. If the difference is less marked, it is called functional inclination.

Software

Two software packages have been used in this research: the SPSS Statistics 19.9 to do the cluster analysis and obtain the main groups of cities in which the world urban system has been classified, and the Adobe Illustrator CS6 has been utilized to map the proposed model based on grids and arrows.

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### Appendix 1. IATA abbreviations.

| Code | City | Country | Code | City | Country | Code | City | Country |
|------|------|---------|------|------|---------|------|------|---------|
| ASIA | LCA  | Nicosia | Cyprus | ATL  | Atlanta | USA  |
| ALA  | LED  | Saint Petersburg | Russia | AUS  | Austin | USA  |
| BJS  | LCA  | Nicosia | Cyprus | BHM  | Birmingham | USA  |
| BKK  | LIS  | Lisbon | Portugal | BOS  | Boston | USA  |
| BLR  | LON  | London | UK | BWI  | Baltimore | USA  |
| BOM  | LPA  | Gran Canaria | Spain | CHI  | Chicago | USA  |
| CAN  | LUX  | Luxembourg | Belgium | CLE  | Cleveland | USA  |
| CCA  | LCA  | Nicosia | Cyprus | CMH  | Columbus | USA  |
| CJS  | MAN  | Manchester | UK | CVG  | Cincinnati | USA  |
| DEL  | MIL  | Milan | Italy | DEN  | Denver | USA  |
| DPS  | MLA  | Malabo | Malacia | DFW  | Dallas | USA  |
| HAN  | MOW  | Moscow | Russia | DTT  | Detroit | USA  |
| HKG  | SAR  | SAR | China | EDD  | Edinburgh | UK  |
| HYD  | MRS  | Marseille | France | HFD  | Hartford | USA  |
| ICAO | MUC  | Munich | Germany | HOU  | Houston | USA  |
| IKT  | NAP  | Naples | Italy | IND  | Indianapolis | USA  |
| KHI  | NCE  | Nice | France | LAS  | Las Vegas | USA  |
| KUL  | NCL  | Newcastle | UK | LAX  | Los Angeles | USA  |
| LHE  | OPO  | Porto | Portugal | MIA  | Miami | USA  |
| MAA  | OSL  | Oslo | Norway | MKC  | Kansas City | USA  |
| MFM  | OXF  | Oxford | UK | MSP  | Minneapolis | USA  |
| MHD  | PAR  | Paris | France | MSY  | New Orleans | USA  |
| MNL  | PDX  | Portland | UK | NAS  | Nassau | Bahamas |
| NGO  | PML  | P. de Mallorca | Spain | NYC  | New York | USA  |
| OSA  | PRG  | Prague | Czech Rep. | ORL  | Orlando | USA  |
| PNQ  | PSA  | Pisa | Italy | PHL  | Philadelphia | USA  |
| SGN  | RIX  | Riga | Latvia | PHX  | Phoenix | USA  |
| SHA  | ROM  | Rome | Italy | PIT  | Pittsburgh | USA  |
| SIN  | SKG  | Singapore | Singapore | RDU  | Raleigh | USA  |
| SZX  | SOF  | Sofia | Bulgaria | SAN  | San Diego | USA  |
| TAE  | STO  | Stockholm | Sweden | SAT  | San Antonio | USA  |
| TPE  | STR  | Stuttgart | Germany | SEA  | Seattle | USA  |
| TYO  | SVQ  | Seville | Spain | SFO  | San Francisco | USA  |
| EUROPE | TLL  | Tallinn | Estonia | STL  | Saint Louis | USA  |
| AGP  | TLS  | Toulouse | France | TPA  | Tampa | USA  |
| ALC  | TGF  | Tenife | Spain | TYS  | Tysons | USA  |
| AMS  | TRN  | Turin | Italy | WAS  | Washington | USA  |
| ATH  | TUN  | Tunisia | Tunisia | YEA  | Edmonton | Canada |
| BNC  | VCE  | Venice | Italy | YMQ  | Montreal | Canada |
| BEG  | VER  | Berlin | Germany | YTO  | Toronto | Canada |
| BGO  | VIE  | Vienna | Austria | YVR  | Vancouver | Canada |
| BLL  | VLC  | Valencia | Spain | YYC  | Calgary | Canada |
| BLQ  | VNO  | Vilnius | Lithuania | EUR  | European | Union |
| BRE  | WAW  | Warsaw | Poland | EUR  | European | Union |
| BRN  | ZAG  | Zagreb | Croatia | ALG  | Algiers | Algeria |
| BRS  | ZAZ  | Zaragoza | Spain | AMM  | Amman | Jordan |
| BRU  | ZRH  | Zurich | Switzerland | AUH  | Abu Dhabi | UAE |
| BSL  | BAH  | Bahamas | USA  |
| BTS  | BEY  | Beirut | Lebanon | EUR  | European | Union |
| BUD  | ANU  | Saint John | Ant. and Barb. | CAI  | Cairo | Egypt |
| BUH  | AUA  | Aruba | Aruba | CMN  | Casablanca | Morocco |
| CGN  | BOG  | Bogota | Colombia | DAM  | Damascus | Syria |
| CPH  | BSB  | Brasilia | Brazil | DMM  | Damman | Saudi Arabia |
| CTA  | BUE  | Buenos Aires | Argentina | DOH  | Doha | Qatar |
| DUB  | CCS  | Caracas | Venezuela | DXB  | Dubai | UAE |
| EDI  | CUN  | Cancun | Mexico | IKA  | Tehran | Iran |
| EIN  | GDL  | Guadalajara | Mexico | JED  | Mecca-Jeddah | Saudi Arabia |
| ESB  | GUA  | Guatemala | Guatemala | KWI  | Kuwait City | Kuwait |
| FAL  | LIM  | Lima | Peru | RAK  | Marrakech | Morocco |
| FLR  | MBJ  | Montego Bay | Jamaica | RAK  | Riyadh | Saudi Arabia |
| FRA  | MX  | Mexico City | Mexico | TLY  | Tel Aviv-Jer. | Israel |
| GLA  | MTC  | Monteved | Uruguay | OCEANIA  | Oceania |
| GNB  | MVD  | Montevideo | Uruguay | OCEANIA  | Oceania |
| GOA  | PNY  | Panama City | Panama | PAL  | Adelaide | Australia |
| Code | City       | Country  | Code | City          | Country          | Code | City        | Country   |
|------|------------|----------|------|---------------|------------------|------|-------------|-----------|
| GOT  | Gothenburg | Sweden   | PUJ  | Punta Cana    | Dominican Rep.   | ARL  | Auckland    | N. Zealand|
| GRO  | Girona     | Spain    | RIO  | Rio de Janeiro| Brazil           | BNE  | Brisbane    | Australia |
| GVA  | Ginebra    | Switzerland | SAL  | San Salvador  | El Salvador      | CBR  | Canberra    | Australia |
| HAJ  | Hanover    | Germany  | SAO  | Sao Paulo     | Brazil           | MEL  | Melbourne   | Australia |
| HAM  | Hamburg    | Germany  | SCL  | Santiago      | Chile            | PER  | Perth       | Australia |
| HEL  | Helsinki   | Finland  | SDQ  | Santo Domingo | Dominican Rep.   | SYD  | Sydney      | Australia |
| HER  | Heraklion  | Greece   | SJD  | San Jose      | Costa Rica       |      |             |           |
| IBZ  | Ibiza      | Spain    | SJU  | San Juan      | Puerto Rico      | SUB  | SUB SAHARAN AFRICA | Cape Town | South Africa |
| IEV  | Kiev       | Ukraine  | UID  | Quito         | Ecuador          | CPT  | Cape Town   | South Africa |
| INN  | Innsbruck  | Austria  |      |               |                  |      |             |           |
| IST  | Istambul   | Turkey   |      |               |                  | LOS  | Lagos       | Nigeria   |
| KRK  | Kraków     | Poland   | ACY  | Atlantic City | USA              | MRU  | Port Louis  | Mauritius |
|      |            |          |      |               |                  | NBO  | Nairobi     | Kenya     |