Statistical Consulting Research Seminar

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How similar are music tastes across countries in the world? An analysis using Spotify's API

Introduction

The main question of this project is "How similar are popular music tastes of countries across the globe?" For example, it could be interesting to explore which are the top 5 countries with popular music tastes more similar to Italy. Moreover, estimating similarities to other countries using a concrete estimate number could elucidate magnitudes of closeness. To attempt to answer it, I used playlist data from Spotify's top 50 songs of each country where such playlist was available. This data was queried from Spotify's API, cleaned, and analyzed using different geometrical distances metrics between each country. Some unexpected associations were unveiled from the analysis suggesting the possibility of discerning proximity in music tastes between countries.

The relevance of such question particularly stems from my interest in analyzing music data, getting experience dealing with API's, using geographical visualizations, and learning about new measures of distance in data. An external benefit from this analysis is the possibility to explore unexpected country associations. Such associations could be useful for musicians of a country, say Italy, to know that one close market for their music is Uruguay, even more than Italy's neighbors. Music festival organizers could also benefit from the insights produced by this analysis in a similar way.

Data retrieval

Spotify API

As mentioned, the process of data collection was completed using Spotify's API integration with R. Specifically, the 'Spotifyr' R wrapper. This wrapper allowed to query the API a limited number of times per minute and download playlist data using the private keys generated for a Spotify user.

The *Uniform Resource Indicator* **(URI)** is a unique identifier for each object in the Spotify API. Songs, artists and playlists have URIs. Hence, the data extraction process required the URIs for each 'Top 50' playlist of each country. Given that at the time of data extraction no database of such URIs existed they had to be individually found.

When sharing a playlist via link, each playlist's URL has embedded the URI of the playlist. After discovering this, I manually extracted all the URLs of each Top 50 playlist. In the process, I discovered two important things: First, Spotify does not generate a 'top 50' playlist for every country in the world. In fact, only 87 countries have a top 50 playlist generated by Spotify. I call these playlists 'official' playlists. Second, there are some 'unofficial' Top 50 playlists for some countries created by private Spotify users. These 'unofficial' playlists proved useful in absence of 'official' Spotify top 50 charts. I collected the URLs for both types of playlists after making sure that the 'unofficial playlists' contained indeed 50 songs, and that those top 50 songs where not added more than two years ago. A total of 115 playlist URLs were obtained this way, one for each country.

Querying data for each country

After manually extracting the URLs of each top 50 playlist, official and unofficial, I proceeded extracting the embedded URIs within each of them. These URIs were the required identifiers to query and download playlist data using the R wrapper. However, the API limits the number of queries for every 30 seconds. To solve this, I introduced a 30-second pause in the script after querying and storing the data of each playlist. The process did not produce any errors and all data files were extracted in a single day.

Merging and cleaning data

One playlist data file was downloaded for each of the 115 countries. Each file contained one row for each of the top 50 most popular songs listened in that country and several columns relating information about the song or the artist. The extraction date of the data was October 26, 2023. All files were then compiled and cleaned to generate a single master data file. In the cleaning process we kept the following variables for each country:

- Country
- Energy
- Loudness
- Major/Minor Key
- Speechiness
- Acousticness
- Danceability
- Liveness
- Valence
- Tempo
- Time Signature
- Popularity
- Instrumentalness

The argument for keeping these variables is that they describe features related to the *music* of the song, while the other variables focused on other aspects of the song different from music. The features were standardized to make the comparisons congruent across variables. More information about these variables can be found in the Spotify API reference site.

Exploratory Data Analysis

Before starting to analyze the data to answer the question of interest, I explored the data to answer other small questions that intrigued me and gave context of the data. Overall, a total of 5742 songs were extracted for 115 countries. One country, Luxembourg, only had 42 songs in its unofficial playlist. The playlists for the remaining countries contained 50 songs each.

Track duration

Figure 1 below displays the density of track duration measured in seconds across all songs. The vertical line displays the average duration of the most popular songs. Such average is is 201 seconds, 3 minutes and 21 seconds. The sample standard deviation is 57 seconds. We see a heavier right tail. A few songs with duration longer than 500 seconds are not displayed in the plot to emphasize on most of the distribution.

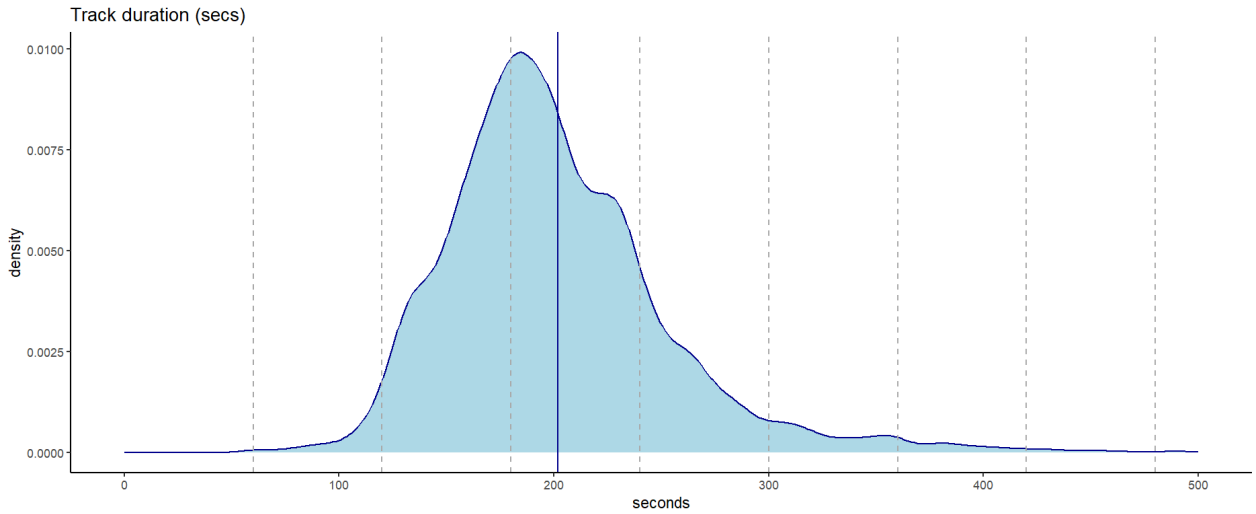

Figure 1. Density of track duration across all songs.

Time signatures

After looking at tempo, I investigated the distribution of time signatures. From previous knowledge I knew that the most common time signature in popular music is 4/4's. However, I did not expect that it encompassed 92% of all songs. Followed just by three beats per measure (3/4's, 6%), and 5/4's (1%).

Common Modes and Keys

Next, I analyzed the key and modality of all songs. 52% of the songs are written on a minor key, respectively 48% are written on a major key. After that, delving into the most common keys I found that the top 3 are C# major (7.7%), B minor (6.5%), and F# minor (6.3%). Keys are, generally, more evenly distributed than other variables.

Tempo

When analyzing tempo across all songs I discovered that the average tempo is 121 beats per minute, with a sample standard deviation of 28 seconds. As a reference, Bad Romance by Lady Gaga or Girls just Wanna Have Fun by Cyndi Lauper have the same tempo. From this, I imagined that on average songs in the top 50 charts are upbeat.

Liveliness vs calmness

Another minor question I explored was trying measure 'liveliness' in the average music of a country. To answer this question, I created a feature approximating how upbeat or calm a song is. I then standardized and pooled together, with equal weights, the following 5 variables: Danceability, Energy, Loudness, Valence and Tempo. I did this for each song and then averaged for each country the new feature 'Liveliness'. Figure 2 presents the geographical representation of this analysis. Brighter colors are associated with higher values in the 5 variables. Darker colors approximate calmer music.

This map suggests that the top 50 songs in Latin American countries and some African countries have the most danceable, loud, energetic, happy (valence) and fast music when comparing to other countries. In the other side of the spectrum, Asian countries, especially Nepal, display calmer, less loud and slower music.

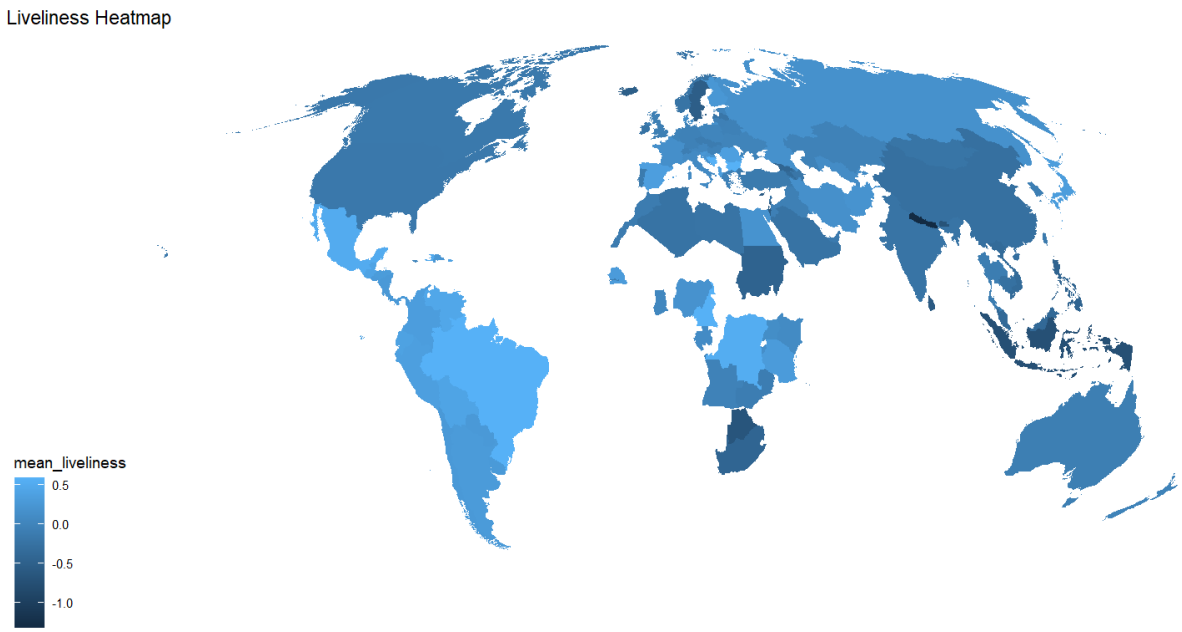

Figure 2. Liveliness heatmap. We can see the case that Latin American countries have the 'Liveliest' music; whereas in South Asian countries music seems to be calmer. The map doesn't show colors for countries for which there's no available data.

Methods

Measuring Closeness

To answer the main question of this project I had to understand and implement methods for measuring distances between *matrices*. From these distances I could figure out the closest countries. I explored two different measures at different levels of granularity.

Euclidean centroid-to-centroid distance

After cleaning and peeking into the data, the first simple analysis I carried out was a Euclidean centroid-to-centroid distance. As mentioned, the task was to compute a distance between matrices, not two data points. That is, how close is the set of 50 observations for country A to the set of 50 observations of country B? The simplest procedure entailed computing the centroid for each country using means, and then calculating the Euclidean distance from centroid of country A to centroid of country B. Figure 3 sketches this approach.

The Euclidean distance between two vectors 'p' and 'q' in 3-dimensions is calculated as[1]:

$$d(p,q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + (p_3 - q_3)^2}$$

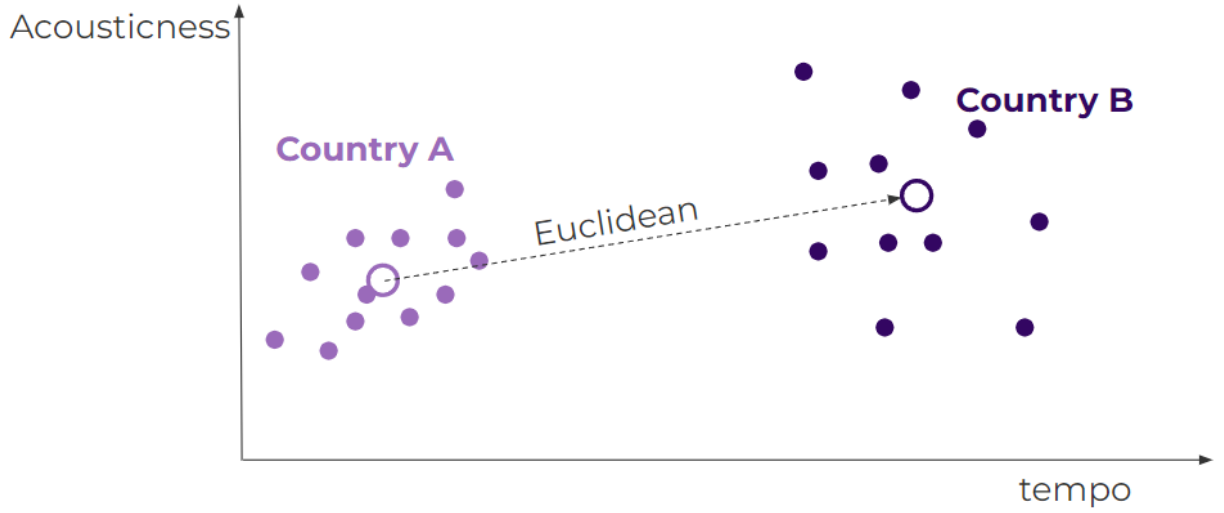

Figure 3. Euclidean centroid-to-centroid distance. This plot is an example.

Mahalanobis centroid-to-centroid distance

As I mentioned in the justification for this project, I wanted to understand other distance measures. One that has intrigued me for some time is the Mahalanobis distance measure. Differently from the Euclidean distance, Mahalanobis distance considers the covariance structure in the data to assess proximity. If a new observation is to be compared to an existing set of points, then the distance between the new observation and the existent set of points is influenced by how the new point fits into the structure of the existing set of points.

[1] Smith, Karl (2013), *Precalculus: A Functional Approach to Graphing and Problem Solving*, Jones & Bartlett Publishers, p. 8, ISBN 978-0-7637-5177-7.

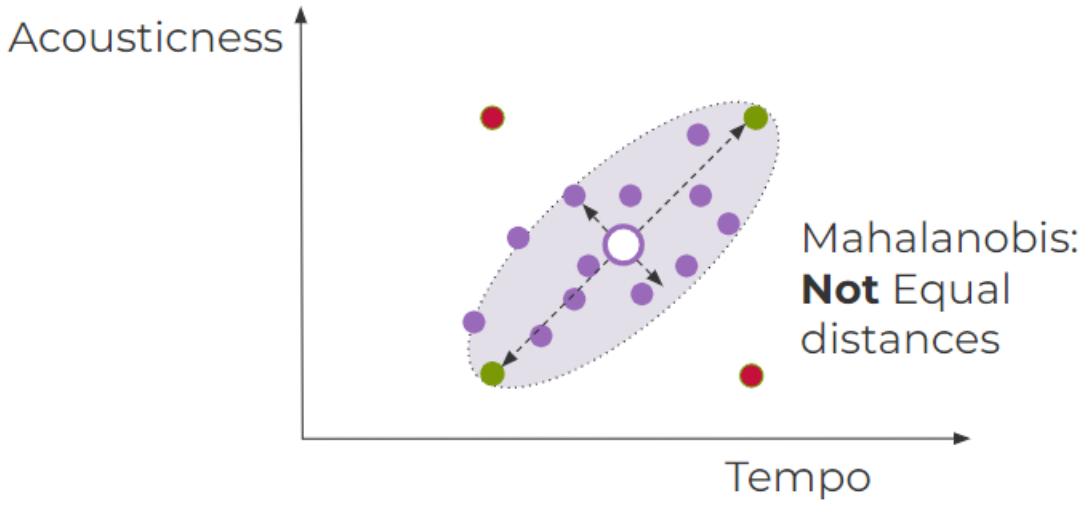

Figure 4. The red points and orange points are equidistant to the centroid when using Euclidean distance. However, Mahalanobis distance assesses the orange points closer to the centroid due to the similarity with the covariance structure of the data. Thus the red points are regarded as further than the orange points from the centroid.

Given a variance-covariance matrix ∑ of a set of points, the Mahalanobis distance between two vectors 'p' and 'q' is calculated as[2]:

$$d_m(\vec{p},\vec{q}) = (\vec{p}-\vec{q})^T \sum^{-1} (\vec{p}-\vec{q})$$

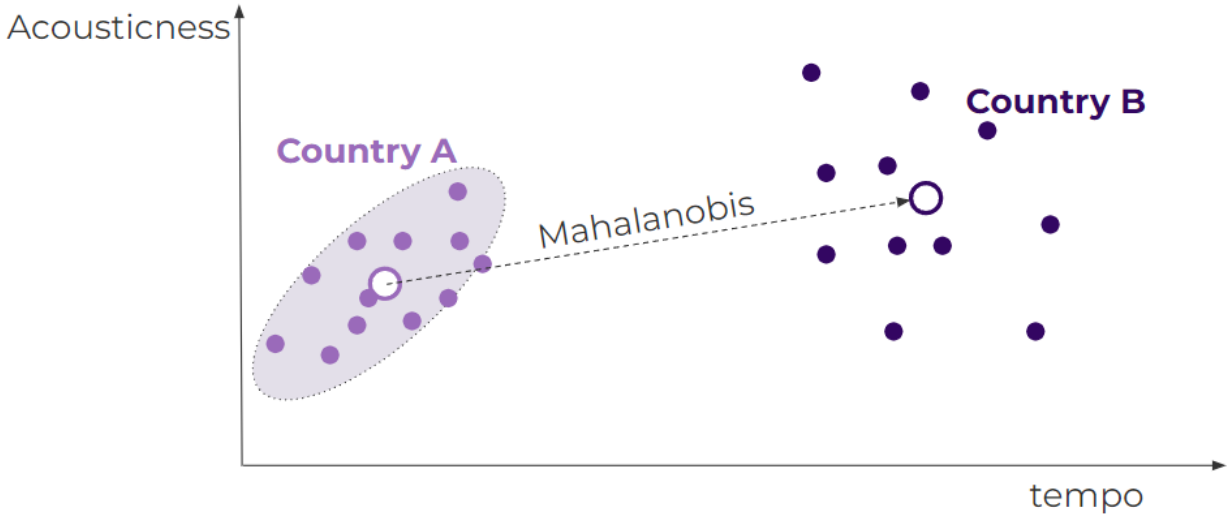

Figure 5. The same procedure as the Euclidean centroid-to-centroid approach was followed but now measuring Mahalanobis distances. The Mahalanobis distance considers the structure of the sparsity of data.

[2] De Maesschalck, R.; Jouan-Rimbaud, D.; Massart, D. L. (2000). "The Mahalanobis distance". *Chemometrics and Intelligent Laboratory Systems*.

The same procedure as the Euclidean measurement was followed with the difference that the required variance-covariance matrix was computed using data from all the centroids. The matrix was invertible and so the Mahalanobis distances could be computed between country centroids.

Mahalanobis centroid-to-song distance

A drawback from the comparison of centroids approach, with both distance measures, is that it collapses all data of countries into centroids, losing some information. For this reason, a more complicated and computationally demanding procedure was followed. First, to measure the distance from country A to country B, I calculated the variance-covariance matrix of country A, as well as its centroid; after that, I computed the Mahalanobis distance from the centroid in country A *to each* of the 50 song observations in country B. Then I averaged all the 50 distances to get a single number reflecting distance. The figure below exemplifies this approach.

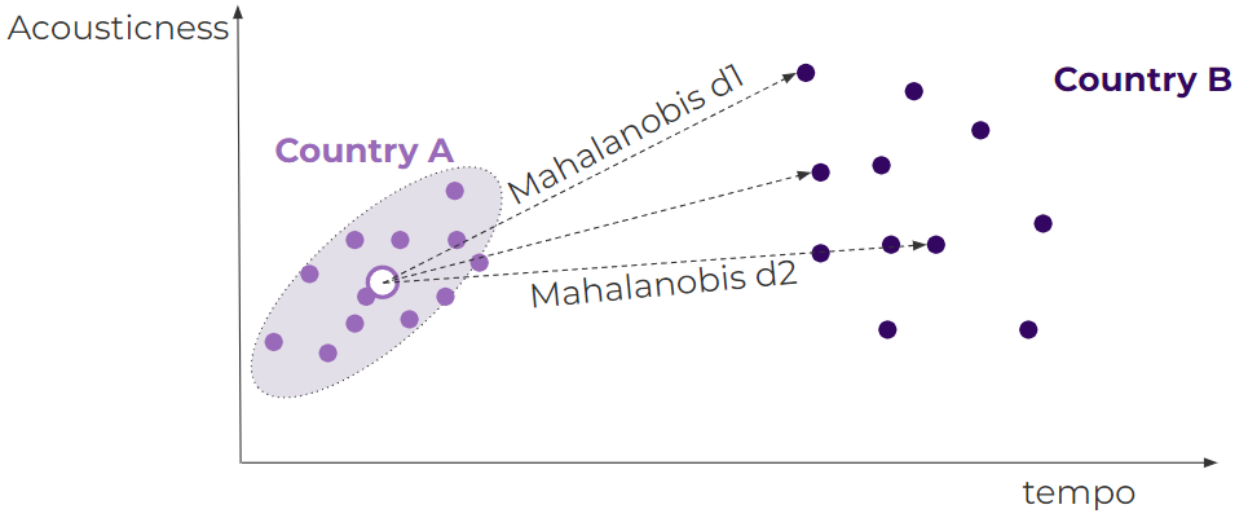

Figure 6. The centroid-to-song Mahalanobis analysis of distance between country A and B computed the Mahalanobis distance between the centroid in country A to each song in country B. The variance-covariance matrix used was that of country A. After calculating the 50 distances, they were pooled to get the single digit distance approximation. No centroid of country B was required this time.

Findings

The three explained methodologies for estimating closeness between playlist were explored: Euclidean centroid-to-centroid, Mahalanobis centroid-to-centroid, Mahalanobis centroid-to-song. Each providing richer insights than the previous one. The appendix section presents the results for each method, presenting the top 5 closest countries to each country in the dataset.

Euclidean centroid-to-centroid

Please refer to Table 1 in the appendix section. This initial approach collapsed each playlist into a mean centroid. From there, Euclidean distances were calculated for each country to estimate its closest neighbors. Given the unsupervised structure of this problem, there is no clear way of assessing correctness in the results. Despite this, the Euclidean centroid-to-centroid measurement presented some *believable* results. In countries such as Germany, Russia and Colombia the top 5 closest countries included countries in their region. In other cases, such as Canada, Brazil and Costa Rica, their top 5 closest countries didn't include other countries in their region or even countries that shared language.

Mahalanobis centroid-to-centroid

Please refer to Table 2 in the appendix section. The Mahalanobis centroid-to-centroid method revealed results in accordance to geographical and historical relationships between countries. Let us explore the results for the three countries mentioned before that did not perform well: Canada's top 5 closest countries consisted in English-speaking countries. Brazil now included Portugal as the closest neighbor, followed by its neighbor Bolivia. For Costa Rica, the top 5 countries were all Latin American countries and 4 of them are also Central American countries.

Mahalanobis centroid-to-song

Please refer to Table 3 in the appendix section. The results for the Mahalanobis centroid-to-song analysis seem to provide the most interesting relationships. Like the previous methodology, this approach uncovers congruent geographical relationships between countries. Moreover, this method revealed some unexpected relationships: migration relationships. In the case of Germany, Turkey was included in its top 5 closest countries. Germany has historically received the highest migration of Turkish people. This same relationship was found in Brazil, with Japan; and in Italy with Argentina. It is important to mention that for 10 countries the methodology was not applicable, since their variance-covariance matrix was not invertible. These are presented as 'NA' in Table 3.

Discussion

The task of this analysis is similar to unsupervised learning tasks: we don't have an exact measure of correctness for our findings. What we can do is explore what the different distance measures suggest. As a reminder, the interest of this project was to understand how close are the music tastes of country A to country B, and explore the relationships of Country A to other countries.

The first methodology, Euclidean centroid-to-centroid distances, provided some initial insights but these did not seem powerful enough. The second method, showed stronger geographical relationships when measuring musical closeness.

The approach that provided the most interesting results was the Mahalanobis centroid-to-song distance calculation. Besides finding regional associations between countries, the Mahalanobis approach discovered migration associations between countries. In Brazil, Germany or Italy these countries don't share language with their Japan, Turkey or Argentina. No Japanese, Turkish or Argentinian songs were found in Brazilian, German or Italian playlists. Even when the music aesthetics of these countries differ, the structures of the features of their popular songs are akin to each other. In other words, the relationship is due to commonalities in the features of the music between countries, nothing more.

Limitations

- This analysis was carried out using data from the *most popular* songs. It could be the case that the association of music tastes is different when analyzing less popular songs.

- A limitation of this analysis is that it leveraged on 'unofficial' top 50 playlists when there was no 'official' Spotify playlist. There is the possibility that these 'unofficial' playlists generated by particular users don't really display the most popular songs of the country.

- One big limitation is the missing data from Central African and South Asian countries. In these countries no 'official' Spotify or 'unofficial' top 50 playlist existed at the time of this analysis. This really reduces the possibility to uncover associations.

- This analysis was carried out using just one wave of data, it could be automated and to explore the stability across time in these relationships.

- For 10 countries in the most detailed Mahalanobis analysis it was impossible to calculate distances because the variance covariance matrix of such country was not invertible.

Next steps

A couple of interesting next steps look appealing for future expansions of the analysis. First, when using ‘official’ Spotify top 50 charts there is a powerful aspect of the data that was not capitalized in this analysis: the song ranking. For example, if the top 1 song in country A is also the top 1 song in country B, the closeness between these two countries could be stronger than that one with country C where the same song is ranking 49. This could not be carried out with ‘unofficial’ playlists where the order of the songs does not represent their popularity.

The second appealing step would be to create an interactive visualization where users could click a country in a map and a heatmap will display the closest and furthest countries. It would be interesting to build an automated data pipeline feeding into such visualization.

Appendix

Table 1. Euclidean centroid-to-centroid results: Top 5 countries

Country	1st	2nd	3rd	4th	5th
Afghanistan	Jamaica	Haiti	Indonesia	Zambia	Cambodia
Albania	Denmark	Turkey	Slovakia	Slovenia	Hungary
Algeria	Spain	Colombia	Puerto Rico	Gabon	El Salvador
Andorra	Guatemala	Paraguay	Belgium	Luxembourg	Bahrain
Angola	Sri Lanka	Taiwan	Azerbaijan	Malaysia	Canada
Argentina	Uruguay	Iceland	Ghana	Lithuania	Hungary
Armenia	Senegal	Cambodia	Zambia	Haiti	South Africa
Australia	UK	Costa Rica	Ireland	Dominican Republic	Iran
Austria	Czech Republic	Finland	Nigeria	Slovenia	Greece
Azerbaijan	Angola	Sri Lanka	Taiwan	Malaysia	Canada
Bahrain	Luxembourg	Bolivia	Burundi	Botswana	Belgium
Belarus	Poland	Cyprus	France	Norway	Uganda
Belgium	Guatemala	Andorra	Paraguay	Luxembourg	Bahrain
Bhutan	Kenya	Cameroon	Georgia	Japan	Thailand
Bolivia	Burundi	Bahrain	Luxembourg	Botswana	Belgium
Bosnia and Herzegovina	Egypt	Algeria	Spain	Canada	Malaysia
Botswana	Burundi	Bolivia	Bahrain	Luxembourg	Morocco
Brazil	Kazakhstan	Sweden	Lithuania	Italy	Netherlands
Bulgaria	Comoros	Peru	Panama	Gambia	South Korea
Burundi	Bolivia	Botswana	Bahrain	Luxembourg	Morocco
Cambodia	Zambia	Haiti	Jamaica	Afghanistan	Indonesia
Cameroon	Bhutan	Kenya	Georgia	Japan	Thailand
Canada	Malaysia	Egypt	Taiwan	Sri Lanka	Angola
Chile	Mexico	Paraguay	Cyprus	Poland	Belarus

China	Japan	Georgia	Congo	Cameroon	Bhutan
Colombia	Puerto Rico	Gabon	El Salvador	USA	Saudi Arabia
Comoros	Bulgaria	Panama	Peru	Gambia	Singapore
Costa Rica	Ireland	Australia	UK	Iran	Israel
Croatia	Netherlands	Italy	Estonia	Sweden	Brazil
Cyprus	Poland	Belarus	France	Norway	Uganda
Czech Republic	Austria	Finland	Nigeria	Slovenia	Greece
Congo	Indonesia	China	Japan	Georgia	Cameroon
Denmark	Albania	Turkey	Slovakia	Slovenia	Hungary
Dominican Republic	New Zealand	United Arab Emirates	UK	Australia	Vietnam
Ecuador	Jordan	Portugal	Sudan	Latvia	Uzbekistan
Egypt	Canada	Malaysia	Taiwan	Sri Lanka	Bosnia and Herzegovina
El Salvador	USA	Gabon	Puerto Rico	Colombia	Saudi Arabia
Estonia	Croatia	Netherlands	Italy	Sweden	Brazil
Finland	Nigeria	Austria	Czech Republic	Slovenia	Greece
France	Belarus	Poland	Norway	Cyprus	Uganda
Gabon	Puerto Rico	Colombia	El Salvador	USA	Saudi Arabia
Gambia	Singapore	Panama	Morocco	Comoros	Bulgaria
Georgia	Japan	Cameroon	Bhutan	Kenya	China
Germany	Ukraine	Russia	Romania	Greece	Czech Republic
Ghana	Hungary	Argentina	Uruguay	Iceland	Lithuania
Greece	Romania	Czech Republic	Austria	Russia	Finland
Guatemala	Belgium	Andorra	Paraguay	Luxembourg	Bahrain
Haiti	Zambia	Cambodia	Jamaica	Afghanistan	Indonesia
Honduras	Saudi Arabia	USA	El Salvador	Gabon	Puerto Rico
Hong Kong	Philippines	Lebanon	India	Zimbawe	Libya
Hungary	Ghana	Argentina	Uruguay	Iceland	Lithuania
Iceland	Uruguay	Argentina	Ghana	Lithuania	Kazakhstan
India	Libya	Philippines	Hong Kong	Lebanon	Zimbawe

Indonesia	Congo	China	Afghanistan	Japan	Jamaica
Iran	Israel	Uzbekistan	Sudan	Portugal	Ireland
Iraq	Tanzania	Mongolia	Thailand	Nepal	Zimbawe
Ireland	Costa Rica	Iran	Israel	Uzbekistan	Australia
Israel	Uzbekistan	Iran	Sudan	Portugal	Jordan
Italy	Netherlands	Croatia	Sweden	Brazil	Estonia
Jamaica	Afghanistan	Haiti	Zambia	Cambodia	Indonesia
Japan	Georgia	Cameroon	China	Bhutan	Kenya
Jordan	Ecuador	Portugal	Sudan	Uzbekistan	Israel
Kazakhstan	Brazil	Sweden	Lithuania	Italy	Netherlands
Kenya	Bhutan	Cameroon	Georgia	Thailand	Japan
Latvia	Venezuela	Nicaragua	South Korea	Ecuador	Jordan
Lebanon	Zimbawe	Nepal	Hong Kong	Philippines	Mongolia
Libya	India	Philippines	Hong Kong	Azerbaijan	Angola
Lithuania	Kazakhstan	Brazil	Sweden	Italy	Netherlands
Luxembourg	Bahrain	Bolivia	Burundi	Belgium	Botswana
Malaysia	Canada	Egypt	Taiwan	Sri Lanka	Angola
Mexico	Chile	Paraguay	Cyprus	Poland	Belarus
Mongolia	Nepal	Zimbawe	Lebanon	Hong Kong	Philippines
Morocco	Singapore	Gambia	Botswana	Panama	Burundi
Nepal	Zimbawe	Mongolia	Lebanon	Hong Kong	Philippines
Netherlands	Italy	Croatia	Sweden	Estonia	Brazil
New Zealand	Dominican Republic	United Arab Emirates	UK	Australia	Vietnam
Nicaragua	South Korea	Venezuela	Latvia	Peru	Ecuador
Nigeria	Finland	Austria	Czech Republic	Slovenia	Greece
Norway	Uganda	Switzerland	France	Belarus	Poland
Panama	Comoros	Gambia	Bulgaria	Singapore	Peru
Paraguay	Andorra	Guatemala	Belgium	Chile	Mexico
Peru	Bulgaria	South Korea	Comoros	Nicaragua	Venezuela
Philippines	Hong Kong	India	Lebanon	Zimbawe	Libya

Poland	Belarus	Cyprus	France	Norway	Uganda
Portugal	Sudan	Uzbekistan	Jordan	Israel	Iran
Puerto Rico	Colombia	Gabon	El Salvador	USA	Saudi Arabia
Romania	Russia	Greece	Czech Republic	Austria	Germany
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Singapore	Morocco	Gambia	Panama	Comoros	Botswana
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South Korea	Nicaragua	Venezuela	Latvia	Peru	Ecuador
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Thailand	Kenya	Bhutan	Cameroon	Tanzania	Iraq
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Uruguay	Argentina	Iceland	Ghana	Lithuania	Hungary
Uzbekistan	Israel	Iran	Sudan	Portugal	Jordan
Venezuela	Nicaragua	South Korea	Latvia	Peru	Ecuador
Vietnam	Honduras	Saudi Arabia	United Arab Emirates	USA	El Salvador

Zambia	Cambodia	Haiti	Jamaica	Afghanistan	Indonesia
Zimbawe	Lebanon	Nepal	Mongolia	Hong Kong	Philippines

Table 2. Mahalanobis centroid-to-centroid results: Top 5 countries

Country	1st	2nd	3rd	4th	5th
Afghanistan	Cameroon	Uzbekistan	Iraq	Armenia	Mexico
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Andorra	Switzerland	Paraguay	Ecuador	Austria	Belgium
Angola	Belarus	Uganda	Ukraine	Saudi Arabia	Estonia
Argentina	Uruguay	Paraguay	Peru	Bolivia	Finland
Armenia	Georgia	Iraq	Estonia	Norway	Zambia
Australia	South Africa	New Zealand	Canada	Cambodia	UK
Austria	Germany	Andorra	Switzerland	Lithuania	Poland
Azerbaijan	Turkey	Switzerland	Luxembourg	Poland	Slovenia
Bahrain	Jordan	Libya	Germany	Gambia	Poland
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Cambodia	Australia	Croatia	Estonia	Ireland	Taiwan
Cameroon	Congo	Hong Kong	Kenya	New Zealand	UK
Canada	USA	Australia	New Zealand	Ireland	UK
Chile	Peru	Puerto Rico	Hungary	Denmark	Ecuador
China	Taiwan	Malaysia	UK	Thailand	New Zealand
Colombia	Ecuador	El Salvador	Peru	Costa Rica	Honduras
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Congo	Cameroon	Senegal	Haiti	UK	Bosnia and Herzegovina
Denmark	Colombia	Puerto Rico	Paraguay	Peru	Gambia
Dominican Republic	Costa Rica	El Salvador	Panama	Honduras	Ecuador
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Egypt	Turkey	Belgium	Switzerland	Luxembourg	Lithuania
El Salvador	Honduras	Costa Rica	Colombia	Ecuador	Nicaragua
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Ghana	Nigeria	Chile	Hungary	Albania	Venezuela
Greece	Hungary	Chile	Gambia	Italy	Peru
Guatemala	Ecuador	Bolivia	Nicaragua	Peru	Colombia
Haiti	Bosnia and Herzegovina	Thailand	Cambodia	Bulgaria	Netherlands
Honduras	El Salvador	Costa Rica	Ecuador	Nicaragua	Paraguay
Hong Kong	Taiwan	Netherlands	Thailand	Ireland	Malaysia
Hungary	Colombia	Tanzania	Italy	Ecuador	Peru
Iceland	Vietnam	Lithuania	Finland	Guatemala	Kazakhstan
India	Switzerland	Singapore	South Korea	Poland	Italy
Indonesia	Malaysia	Saudi Arabia	China	UK	Ireland
Iran	Israel	Libya	Azerbaijan	Uzbekistan	South Korea
Iraq	Lebanon	Israel	Georgia	Iran	Armenia
Ireland	South Africa	Philippines	UK	Canada	New Zealand

Israel	Norway	Iran	Azerbaijan	USA	Canada
Italy	Tanzania	Venezuela	Singapore	Switzerland	Peru
Jamaica	Finland	Denmark	New Zealand	Sweden	Nigeria
Japan	China	Thailand	Taiwan	New Zealand	UK
Jordan	Germany	Slovenia	Sudan	Poland	Denmark
Kazakhstan	Ukraine	Andorra	Austria	Vietnam	Germany
Kenya	UK	Croatia	Zambia	Saudi Arabia	South Korea
Latvia	South Africa	Zimbawe	Norway	Australia	Canada
Lebanon	Georgia	Iraq	Iran	Bosnia and Herzegovina	Norway
Libya	Jordan	Slovenia	Azerbaijan	Bahrain	Poland
Lithuania	Finland	Austria	Switzerland	Estonia	Netherlands
Luxembourg	France	Spain	Belgium	Colombia	Switzerland
Malaysia	Taiwan	China	Philippines	UK	New Zealand
Mexico	Guatemala	Bolivia	Nicaragua	Ecuador	Finland
Mongolia	Slovenia	Estonia	Georgia	Norway	Belarus
Morocco	France	Andorra	Poland	Hungary	Luxembourg
Nepal	Sweden	Indonesia	Bhutan	Cambodia	Philippines
Netherlands	Georgia	Belgium	Philippines	Ireland	Hong Kong
New Zealand	South Africa	Australia	Canada	UK	Ireland
Nicaragua	El Salvador	Honduras	Costa Rica	Ecuador	Colombia
Nigeria	Ghana	Chile	Tanzania	Lithuania	Hungary
Norway	Zimbawe	Latvia	El Salvador	USA	Canada
Panama	Costa Rica	Dominican Republic	El Salvador	Honduras	Spain
Paraguay	Peru	Bolivia	Ecuador	Honduras	El Salvador
Peru	Ecuador	Paraguay	Bolivia	Colombia	El Salvador
Philippines	Ireland	Singapore	Belgium	New Zealand	Malaysia
Poland	Tanzania	Zimbawe	Switzerland	UK	Ireland
Portugal	Andorra	Germany	Kazakhstan	Sudan	Spain
Puerto Rico	Colombia	Peru	Honduras	El Salvador	Denmark
Romania	Vietnam	Tanzania	Austria	Peru	Ecuador

Russia	Germany	Jordan	Austria	Slovenia	Romania
Saudi Arabia	South Africa	Kenya	Belgium	United Arab Emirates	Cyprus
Senegal	Congo	Germany	Cameroon	Kenya	Armenia
Singapore	Switzerland	Philippines	United Arab Emirates	South Korea	Slovenia
Slovakia	Czech Republic	Algeria	Dominican Republic	Austria	El Salvador
Slovenia	Tanzania	Singapore	Jordan	Burundi	Finland
South Africa	Ireland	United Arab Emirates	UK	USA	Latvia
South Korea	Singapore	Switzerland	Taiwan	Slovenia	Malaysia
Spain	El Salvador	Costa Rica	Belgium	Luxembourg	Ecuador
Sri Lanka	India	Morocco	Philippines	Switzerland	Ireland
Sudan	Jordan	Germany	Cyprus	Poland	Gambia
Sweden	Philippines	Andorra	Belgium	Morocco	Denmark
Switzerland	Andorra	Singapore	Tanzania	Peru	Paraguay
Taiwan	Malaysia	China	New Zealand	Thailand	Singapore
Tanzania	Germany	Croatia	Slovenia	Switzerland	Italy
Thailand	Ireland	Taiwan	China	Hong Kong	Australia
Turkey	Egypt	Azerbaijan	Luxembourg	Algeria	Cyprus
UK	South Africa	New Zealand	Ireland	Australia	Canada
USA	South Africa	Canada	Australia	New Zealand	Ireland
Uganda	Belarus	Venezuela	Kenya	Tanzania	Burundi
Ukraine	Kazakhstan	Ecuador	Lithuania	Vietnam	Belarus
United Arab Emirates	South Africa	Singapore	New Zealand	Australia	UK
Uruguay	Argentina	Paraguay	Peru	Denmark	Bolivia
Uzbekistan	Belarus	Iran	Nicaragua	Switzerland	Italy
Venezuela	Peru	Andorra	Ecuador	Paraguay	Italy
Vietnam	Romania	Austria	Kazakhstan	Iceland	Lithuania
Zambia	Estonia	Kenya	UK	South Africa	Saudi Arabia
Zimbawe	Latvia	Norway	Australia	Poland	Canada

Table 3. Mahalanobis centroid-to-song results: Top 5 countries

Country	1st	2nd	3rd	4th	5th
Afghanistan	NA	NA	NA	NA	NA
Albania	Bosnia and Herzegovina	Russia	Turkey	Croatia	Lebanon
Algeria	Jordan	Bosnia and Herzegovina	Haiti	Iran	Libya
Andorra	Argentina	Uruguay	Bolivia	Costa Rica	Chile
Angola	Albania	Burundi	Russia	Bosnia and Herzegovina	Tanzania
Argentina	Uruguay	Bolivia	Puerto Rico	Taiwan	Japan
Armenia	NA	NA	NA	NA	NA
Australia	Canada	USA	Singapore	New Zealand	UK
Austria	Singapore	Germany	Italy	Switzerland	United Arab Emirates
Azerbaijan	Albania	Turkey	Egypt	India	Russia
Bahrain	Jordan	Algeria	Haiti	Bosnia and Herzegovina	Iran
Belarus	India	Albania	Croatia	Russia	South Korea
Belgium	Singapore	Malaysia	Taiwan	South Korea	United Arab Emirates
Bhutan	Cambodia	Haiti	Lebanon	Iran	Bosnia and Herzegovina
Bolivia	Argentina	Uruguay	Japan	Taiwan	Puerto Rico
Bosnia and Herzegovina	NA	NA	NA	NA	NA
Botswana	Bhutan	Burundi	Bahrain	Comoros	Gabon
Brazil	Bolivia	Japan	Argentina	Uruguay	Peru
Bulgaria	Denmark	Romania	Bosnia and Herzegovina	Albania	Chile
Burundi	Bhutan	Bosnia and Herzegovina	Mongolia	Haiti	Lebanon
Cambodia	Haiti	Bosnia and Herzegovina	Iran	Japan	Taiwan

Cameroon	Bosnia and Herzegovina	Haiti	Iraq	Egypt	Albania
Canada	Australia	USA	Singapore	New Zealand	UK
Chile	Argentina	Uruguay	Bolivia	Turkey	Puerto Rico
China	Japan	Thailand	Cambodia	Taiwan	Croatia
Colombia	Ecuador	Costa Rica	Peru	Honduras	El Salvador
Comoros	Bhutan	Bosnia and Herzegovina	Iraq	Gabon	Iran
Costa Rica	Peru	Ecuador	Honduras	El Salvador	Colombia
Croatia	Albania	Japan	Bosnia and Herzegovina	Argentina	Thailand
Cyprus	Turkey	Singapore	United Arab Emirates	Malaysia	Poland
Czech Republic	Slovakia	Greece	Hungary	Italy	France
Congo	Haiti	Bosnia and Herzegovina	Cameroon	Albania	Gabon
Denmark	Uruguay	Taiwan	Argentina	Hong Kong	Bolivia
Dominican Republic	Costa Rica	Colombia	Spain	Ecuador	Peru
Ecuador	Costa Rica	Peru	Honduras	El Salvador	Colombia
Egypt	Turkey	India	Japan	Thailand	Russia
El Salvador	Honduras	Costa Rica	Ecuador	Colombia	Peru
Estonia	United Arab Emirates	Singapore	Lithuania	Chile	UK
Finland	Denmark	Italy	Albania	Hungary	Poland
France	Denmark	Poland	Singapore	Luxembourg	Albania
Gabon	Algeria	Bahrain	Burundi	Bhutan	Jordan
Gambia	Albania	Burundi	Gabon	Jordan	Bosnia and Herzegovina
Georgia	Lebanon	Iraq	Mongolia	Burundi	Bosnia and Herzegovina
Germany	Denmark	Greece	Poland	France	Turkey
Ghana	Albania	Nigeria	Poland	Hungary	Italy
Greece	Denmark	Poland	Hungary	Turkey	Romania
Guatemala	Mexico	Ecuador	Nicaragua	Peru	Bolivia

Haiti	Bosnia and Herzegovina	Iran	Cambodia	Japan	Jordan
Honduras	Costa Rica	El Salvador	Ecuador	Peru	Colombia
Hong Kong	Taiwan	Japan	Bolivia	Uruguay	Argentina
Hungary	Greece	Poland	Albania	Romania	Denmark
Iceland	Taiwan	Singapore	Thailand	Japan	Hong Kong
India	NA	NA	NA	NA	NA
Indonesia	Singapore	Malaysia	Taiwan	Japan	Thailand
Iran	Bosnia and Herzegovina	Haiti	Jordan	Cambodia	Algeria
Iraq	NA	NA	NA	NA	NA
Ireland	Singapore	Taiwan	Malaysia	Australia	UK
Israel	Taiwan	Hong Kong	Turkey	Japan	Uruguay
Italy	Argentina	Uruguay	Denmark	Greece	Thailand
Jamaica	NA	NA	NA	NA	NA
Japan	Taiwan	Hong Kong	Uruguay	Argentina	Bolivia
Jordan	Bosnia and Herzegovina	Iran	Haiti	Taiwan	Algeria
Kazakhstan	Finland	Hungary	Egypt	Albania	Italy
Kenya	India	Albania	Tanzania	Croatia	Thailand
Latvia	Singapore	United Arab Emirates	Australia	Canada	UK
Lebanon	NA	NA	NA	NA	NA
Libya	Algeria	Iran	Jordan	Bahrain	Bosnia and Herzegovina
Lithuania	Singapore	United Arab Emirates	Australia	South Korea	Chile
Luxembourg	Singapore	Australia	UK	Canada	Chile
Malaysia	Singapore	Taiwan	Hong Kong	Thailand	Canada
Mexico	Bolivia	Chile	Guatemala	Uruguay	Argentina
Mongolia	Burundi	Bosnia and Herzegovina	Iraq	Lebanon	Georgia
Morocco	Denmark	Chile	Argentina	Uruguay	Bolivia
Nepal	NA	NA	NA	NA	NA

Netherlands	Singapore	Thailand	Taiwan	Malaysia	United Arab Emirates
New Zealand	Australia	Singapore	Canada	USA	UK
Nicaragua	Costa Rica	Ecuador	Honduras	El Salvador	Peru
Nigeria	Greece	Turkey	Italy	Albania	Russia
Norway	Singapore	Malaysia	Taiwan	Belgium	Denmark
Panama	Costa Rica	Peru	Chile	Colombia	Honduras
Paraguay	Bolivia	Peru	Ecuador	Argentina	Costa Rica
Peru	Costa Rica	Ecuador	Bolivia	Chile	Argentina
Philippines	Singapore	Malaysia	Thailand	Taiwan	Hong Kong
Poland	Denmark	Turkey	Uruguay	Argentina	Taiwan
Portugal	Singapore	Egypt	Argentina	India	United Arab Emirates
Puerto Rico	Argentina	Uruguay	Bosnia and Herzegovina	Bolivia	Japan
Romania	Poland	Albania	Denmark	Greece	Bulgaria
Russia	NA	NA	NA	NA	NA
Saudi Arabia	Singapore	United Arab Emirates	Malaysia	Japan	Thailand
Senegal	Burundi	Iraq	Afghanistan	Bosnia and Herzegovina	Haiti
Singapore	Malaysia	Taiwan	Hong Kong	Japan	Canada
Slovakia	Czech Republic	France	Greece	Germany	Poland
Slovenia	Croatia	Albania	South Korea	Uruguay	Thailand
South Africa	Singapore	Thailand	Poland	Taiwan	India
South Korea	Thailand	Singapore	Japan	Taiwan	India
Spain	NA	NA	NA	NA	NA
Sri Lanka	Thailand	Taiwan	India	Nepal	Hong Kong
Sudan	Lebanon	Haiti	Algeria	Bosnia and Herzegovina	Gabon
Sweden	Hong Kong	Denmark	Malaysia	Singapore	Taiwan
Switzerland	Singapore	Luxembourg	UK	Australia	Argentina
Taiwan	Hong Kong	Japan	Uruguay	Argentina	Bolivia
Tanzania	Albania	Bosnia and Herzegovina	Egypt	Croatia	India

Thailand	Japan	Taiwan	Singapore	Hong Kong	Malaysia
Turkey	Japan	Argentina	Uruguay	Taiwan	Bolivia
UK	Australia	Canada	Singapore	USA	New Zealand
USA	Canada	Australia	Singapore	Bolivia	UK
Uganda	Nigeria	Albania	Tanzania	Croatia	Thailand
Ukraine	Lithuania	Finland	Poland	Turkey	Russia
United Arab Emirates	Singapore	Canada	Australia	UK	New Zealand
Uruguay	Argentina	Bolivia	Puerto Rico	Taiwan	Japan
Uzbekistan	Egypt	Bosnia and Herzegovina	Albania	Croatia	Slovenia
Venezuela	Spain	Chile	Colombia	Costa Rica	India
Vietnam	Thailand	South Korea	India	Taiwan	Singapore
Zambia	Japan	Bosnia and Herzegovina	India	Croatia	Slovenia
Zimbawe	Albania	Chile	Thailand	Puerto Rico	Egypt