globaltrends

Download and measure global trends through Google searches

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```
library(globaltrends)
```

Google Trends

Google offers public access to global search volumes through its search engine through the Google Trends portal. Users select keywords for which they want to obtain search volumes and specify the timeframe and location (global, country, state, community) of interest. For these combinations of keywords, period, and location Google Trends provides search volumes that indicate the number of search queries submitted to the Google search engine. The `globaltrends` package downloads these search volumes from Google Trends and uses them to measure and analyze the distribution of search volumes across or within locations. `globaltrends` allows researchers and analysts to investigate patterns within search volumes, such as degree of internationalization of firms and organizations or dissemination of political, social, or technological trends across the globe or within single countries.

With the help of the `globaltrends` package, researches and analysts can compute and investigate three measures on Google searches for objects of interest. Local search searches provide insights into the local relevance of objects and the exposure of these objects to the respective locations. Global search scores track the worldwide relevance of objects and approximate their volume of internationalization. The across-country distribution of search scores relates to the degree of internationalization of objects of interest.

Google Trends as a measure of firm internationalization

The `globaltrends` package computes two conceptually distinct measures of firm internationalization capturing the **volume of internationalization** (**VOI**) and the **degree of internationalization** (**DOI**). We do so since the absolute search volumes for firms is conceptually different from its international distribution. In the figure below, we illustrate this differentiation and analyze the internationalization of the *fidget spinner* toy, a product with a very distinctive, fad-like internationalization history. The *fidget spinner* was invented and commercialized in late 2016 and became the world's most sold toy within only two months of commercialization. After 2017, interest in the *fidget spinner* somewhat resided, but remained highly globalized. In other words, the *fidget spinner* internationalized at a very fast pace and interest in the product is still evenly distributed across the globe, but this interest remains at a much lower overall volume. By creating two separate measures, we can capture both global search volumes as wells as the distribution of search volumes across the globe, allowing for more fine-grained analysis and interactions between these distinguishable concepts of firm internationalization.

In the `globaltrends` package, we provide a tailor-made operationalization of firm internationalization that does not approximate the configuration of the firm's international operations but relies on their global recognition. Our package allows users to download time series of Google search volumes from 2004 onwards. Because Google Trends organizes its data output as single-country keyword batches, the package uses batched downloads. Within these batches, Google Trends normalizes search volumes to values between 0 and 100. We

devise a mapping algorithm to transform Google Trends output to a more general data structure. For each country, we download a set of baseline keywords that captures "standard" search volumes in the country. We then download batches of company names, including synonyms and alternative spellings, for each country. Next, we follow Castelnuovo and Tran (2017) to map search volumes for firms to search volumes for baseline keywords in each country. We then use these time series to compute search scores as the ratio between the search volumes for a firm in comparison to search volumes for the baseline keywords in each country.

Search scores are interpretable as the proportion of search volumes for a company compared to search volumes for the baseline keywords within a country. Search scores therefore allow comparison across companies, dates, and countries and provide insights into the local relevance of companies and the exposure of these companies to the respective countries.

Volume of internationalization (VOI)

Country search scores focus on search volumes for companies in single countries. To compute a company's volume of internationalization, we focus on global search volumes instead of country search volumes. Using the same approach as outlined above, we first download global search volumes for each baseline keyword and firm. Next, we map the time series and compute global search scores as the ratio of global search volumes for each firm and global baseline search volumes.

Like country search scores, we can interpret global search scores as the proportion of global search volumes for a company compared to global search volumes for baseline keywords. This allows researchers to track changes in global interest in companies and highlights phases of fast or receding internationalization. Since the computation of country and global search scores follows the same procedures, the two measures have the same properties. This provides for a direct comparison between country search scores and volume of internationalization in terms of global search scores.

Degree of internationalization (DOI)

As the main measure for a firm's degree of internationalization, the `globaltrends` package uses on the global dispersion of country search scores. The more uniform the distribution of search scores across countries, the higher a firm's degree of internationalization. When the distribution of country search scores is highly skewed, with high search scores in the firm's home country and low search scores in other countries, the firm has a low degree of internationalization. To compute a firm's degree of internationalization, the packages by default uses as the inverted Gini coefficient.

Case study: Analyzing firm internationalization

We demonstrate the functionality of the `globaltrends` package based on a sample of six large U.S. firms. For a more extensive academic application of the `globaltrends` package, please refer to Venger, Puhr, and Müllner (2020), available on Github. In this brief case study, we analyze the degree of internationalization of *Alaska Air Group Inc.*, *Coca-Cola Company*, *Facebook Inc.*, *Illinois Tool Works Inc.*, *J.M. Smucker Company*, and *Microsoft Corporation*. The workflow consists of four major steps:

1. Setup and start database
2. Download data from Google Trends
3. Compute search score and internationalization
4. Exports and plots

Setup and start database

Research projects that use Google Trends generate a substantial amount of data. To optimally handle this data, the `globaltrends` package uses a SQLite database to store and handle all data. This ensures efficiency and portability on the one hand and seamless integration with functions implemented in the `DBI` and `dplyr` packages on the other hand.

Users create the underlying database through the `initialize_db` command. The command creates a folder named *db* within the current working directory and creates a SQLite database file named *globaltrends_db.sqlite* within this folder. The command also creates all necessary tables within the database. For more information on database tables, please refer to their built-in documentation, e.g. `?globaltrends::data_score`. The database initialization is necessary only for the first usage of the `globaltrends` package.

```
setwd("your/globaltrends/folder")
initialize_db()
#> Database has been created.
#> Table 'batch_keywords' has been created.
#> ...
#> Table 'data_global' has been created.
#> Successfully disconnected.
```

After initialization or when resuming work on an existing database it is sufficient to call `start_db` from the respective working directory. This command connects to the *globaltrends.sqlite* database in the folder *db* and creates connections to all tables in the database.

```
setwd("your/globaltrends/folder")
start_db()
#> Successfully connected to database.
#> Successfully exported all objects to .GlobalEnv.
print(ls())
#>  [1] "batch_keywords"   "batch_time"       "countries"        "data_control"
#>  [5] "data_doi"         "data_global"      "data_locations"   "data_mapping"
#>  [9] "data_object"      "data_score"       "dir_current"      "dir_wd"
#> [13] "globaltrends_db"  "keyword_synonyms" "keywords_control" "keywords_object"
#> [17] "time_control"     "time_object"      "us_states"
```

After all work with the `globaltrends` package is complete, the user disconnects from the database with the command `disconnect_db`.

```
disconnect_db()
#> Successfully disconnected.
```

Download data from Google Trends

The next step in the `globaltrends` workflow is the data download from Google Trends. The `globaltrends` package includes four types of download functions that we explain in detail below. Each of these functions uses the `gtrendsR::gtrends` function to access the Google Trends API. The Google Trends API allows inputs of up to five keywords for a given location and period. Therefore, the `globaltrends` package works with "keyword batches" that combine up to five keywords. The respective batch numbers are an input to all functions – either as `list` or as single `integer` objects. In the package, we distinguish two types of batches: **control** batches that include baseline keywords and **object** batches that include keywords relating to the objects of interest (e.g. firms, persons, trends...). Currently, `globaltrends` only includes two sets of locations. The *countries* set, which covers all countries that generated at least 0.1% of world GDP in 2018 and the *us_states* set, covering all US states and Washington DC, see below for further details.

The download for a single keyword batch for a single location takes about 30 seconds. This includes a randomized waiting period of 20-30 seconds between downloads. Depending on the frequency of downloads, Google Trends might block users for some time. In this case, `globaltrends` waits 60 minutes before it retries the download.

Download control data

First, we add a batch of control keywords to the database using `add_control_keyword`. Since *gmail*, *maps*, *translate*, *wikipedia*, and *youtube* allow an approximation of "standard" search volumes on Google, we propose them as baseline keywords for global trend analysis. These keywords proxy the baseline search traffic on Google. For specific research settings, we suggest adapting keywords to the respective setting and testing them on the Google Trends portal beforehand. The output of `add_control_keyword` is a `list` object that can serve as input for other functions.

```
new_control <- add_control_keyword(
  keyword = c("gmail", "maps", "translate", "wikipedia", "youtube"),
  time = "2010-01-01 2019-12-31"
)
#> Successfully created new control batch 1 (gmail ... youtube, 2010-01-01 2019-12-31).
```

The function `add_control_keyword` also updates the object `keywords_control` in the global environment. This `tibble` can be used for batch lookup.

```
dplyr::filter(keywords_control, keyword == "gmail")
#> # A tibble: 1 x 2
#>   batch keyword
#>   <int> <chr>
#> 1     1 gmail
```

As a second step, we download the control data with `download_control`, using the output from `add_control_keyword` as `control` input. The input `locations` defaults to `countries`, see below for further details.

```
download_control(control = new_control, locations = countries)
#> Successfully downloaded control data | control: 1 | location: US [1/66]
#> ...
#> Successfully downloaded control data | control: 1 | location: DO [66/66]
```

A message indicates each successful download volumes for control keywords. The data is written directly to the database. The function `download_control_global` follows the same approach and downloads control data on a global level.

```
download_control_global(control = new_control)
#> Successfully downloaded control data | control: 1 | location: world [1/1]
```

Download object data

For object data, as for control data, the first step is to add keywords that correspond to the objects of interest. While we use a single control batch for the entire analysis, there are more than one object batch, consisting of up to four keywords. Before we add the object keywords, we clean them, deleting punctuation and form of incorporation: *alaska air group*, *coca cola*, *facebook*, *Illinois tool works*, *jm smucker*, and *microsoft*. Since this affects search results, the transformation requires substantial consideration and depends on the respective research setting. To ensure the expected results, we propose testing keyword transformations on the Google Trends portal beforehand.

```
new_object <- add_object_keyword(
  keyword = list(
    c("coca cola", "facebook", "microsoft"),
    c("alaska air group", "illinois tool works", "jm smucker")
  ),
  time = "2010-01-01 2019-12-31"
)
#> Successfully created new object batch 1 (coca cola ... microsoft, 2010-01-01 2019-12-31).
#> Successfully created new object batch 2 (alaska air group ... jm smucker, 2010-01-01 2019-12-31).
```

As for control keywords, the function `add_object_keyword` also updates the object `keywords_object` in the global environment. This `tibble` can be used for batch lookup.

```
dplyr::filter(keywords_object, keyword == "coca cola")
#> # A tibble: 1 x 2
#>   batch keyword
#>   <int> <chr>
#> 1     1 coca cola
```

Again, the second step is to download the object data with `download_object`, using the output from `add_object_keyword` as `object` input. As above, the input `locations` defaults to `countries`. The package adds a control keyword to each batch of four object keywords. This control keyword then allows a mapping between control batches and object batches.

```
download_object(object = new_object, locations = countries)
#> Successfully downloaded object data | object: 1 | location: US [1/66]
#> ...
#> Successfully downloaded object data | object: 2 | location: DO [66/66]
```

A message indicates each successful download of search volumes for object keywords. The data is written directly to the database. The function `download_object_global` follows the same approach and downloads object data on a global level.

```
download_object_global(object = new_object)
#> Successfully downloaded object data | object: 1 | location: world [1/1]
#> Successfully downloaded object data | object: 2 | location: world [1/1]
```

Compute search scores and internationalization

Once the user has completed all control and object downloads, `globaltrends` computes search scores for each keyword-date-location combination and at a global level (*volume of internationalization*). Next, the package uses the across-country distribution of these search scores to measure the *degree of internationalization* of an object keyword.

Compute country search scores and volume of internationalization

The function `compute_score` divides the search volumes for an object keyword by the sum of search volumes for the keywords in the respective control batch. The search score computation proceeds in four steps. First, the function aggregates all search volumes to monthly data. Then, it applies some optional time series adjustments that we outline in greater detail below. Next, it follows the procedure outlined by Castelnuovo and Tran (2017, pp. A1-A2) to map control and object data. After the mapping, object search volumes are divided by the sum of control search volumes in the respective control batch. We use the sum of search volumes for a set of control keywords, rather than the search volumes for a single control keyword, to

smooth-out variation in the underlying control data. Because of this division, it is essential to define a set of baseline keywords that mirrors "standard" Google usage for the given research setting.

```
compute_score(control = new_control[[1]], object = new_object, locations = countries)
#> Successfully computed search score | control: 1 | object: 1 | location: US [1/66]
#> ...
#> Successfully computed search score | control: 1 | object: 2 | location: DO [66/66]
```

A message indicates each successful computation of search scores. The data is written directly to the database. The computation of the volume of internationalization follows the same principles. Instead of search volumes of baseline and object keywords at the country level, the function `compute_voi` compares baseline and object search volumes at the global level.

```
compute_voi(control = new_control[[1]], object = new_object)
#> Successfully computed search score | control: 1 | object: 1 | location: world [1/1]
#> Successfully computed search score | control: 1 | object: 2 | location: world [1/1]
```

Compute degree of internationalization

The `globaltrends` package uses the distribution of search scores across countries to compute the degree of internationalization for objects of interest. The function `compute_doi` uses an inverted Gini-coefficient as measure for the degree of internationalization. The more uniform the distribution of search scores across all countries, the higher the inverted Gini-coefficient and the greater the degree of internationalization. In addition to the Gini-coefficient, the package uses inverted Herfindahl index and inverted Entropy as measures for internationalization (details below).

```
compute_doi(control = new_control[[1]], object = new_object, locations = "countries")
#> Successfully computed DOI | control: 1 | object: 1 [1/2]
#> Successfully computed DOI | control: 1 | object: 2 [2/2]
```

A message indicates each successful computation. The data is written directly to the database.

Exports and plots

`globaltrends` writes all data directly to the database. With the help of functions from the `dplyr` package and connections exported from `start_db`, users can access database tables.

```
library(dplyr)
data_score %>%
  filter(keyword == "coca cola") %>%
  collect()

#> # A tibble: 8,040 x 8
#>    location keyword    date score_obs score_sad score_trd batch_c batch_o
#>    <chr>    <chr>     <int>     <dbl>     <dbl>     <dbl>   <int>   <int>
#>  1 US       coca cola 14610   0.00362   0.00381   0.00548       1       1
#>  ...
#> 10 US       coca cola 14883   0.00347   0.00365   0.00389       1       1
#> # ... with 8,030 more rows
```

To enhance usability, the `globaltrends` package includes a set of export functions that offer some filters and return data as `tibble`. Currently the functions do not include `list` inputs – users are advised to `purrr::map_dfr` or `dplyr::filter` instead.

```
export_control(control = 1)

#> # A tibble: 39,600 x 5
#>    location keyword date        hits control
#>    <chr>    <chr>   <date>     <dbl>   <int>
#>  1 US       gmail   2010-01-01    22       1
#>  ...
#> 10 US       gmail   2010-10-01    27       1
#> # ... with 39,590 more rows

export_score(object = 1, control = 1)

#> # A tibble: 23,760 x 8
#>    location keyword   date       score_obs score_sad score_trd control object
#>    <chr>    <chr>     <date>         <dbl>     <dbl>     <dbl>   <int>  <int>
#>  1 US       coca cola 2010-01-01   0.00362   0.00381   0.00548       1      1
#>  ...
#> 10 US       coca cola 2010-10-01   0.00347   0.00365   0.00389       1      1
#> # ... with 23,750 more rows

purrr::map_dfr(c("coca cola", "microsoft"), export_doi, control = 1, type = "obs")

#> # A tibble: 240 x 9
#>    keyword   date       type       gini   hhi entropy control object locations
#>    <chr>     <date>     <chr>     <dbl> <dbl>   <dbl>   <int>  <int> <chr>
#>  1 coca cola 2010-01-01 score_obs 0.397 0.874  -0.938       1      1 countries
#>  ...
#> 10 coca cola 2010-10-01 score_obs 0.574 0.968  -0.303       1      1 countries
#> # ... with 230 more rows
```

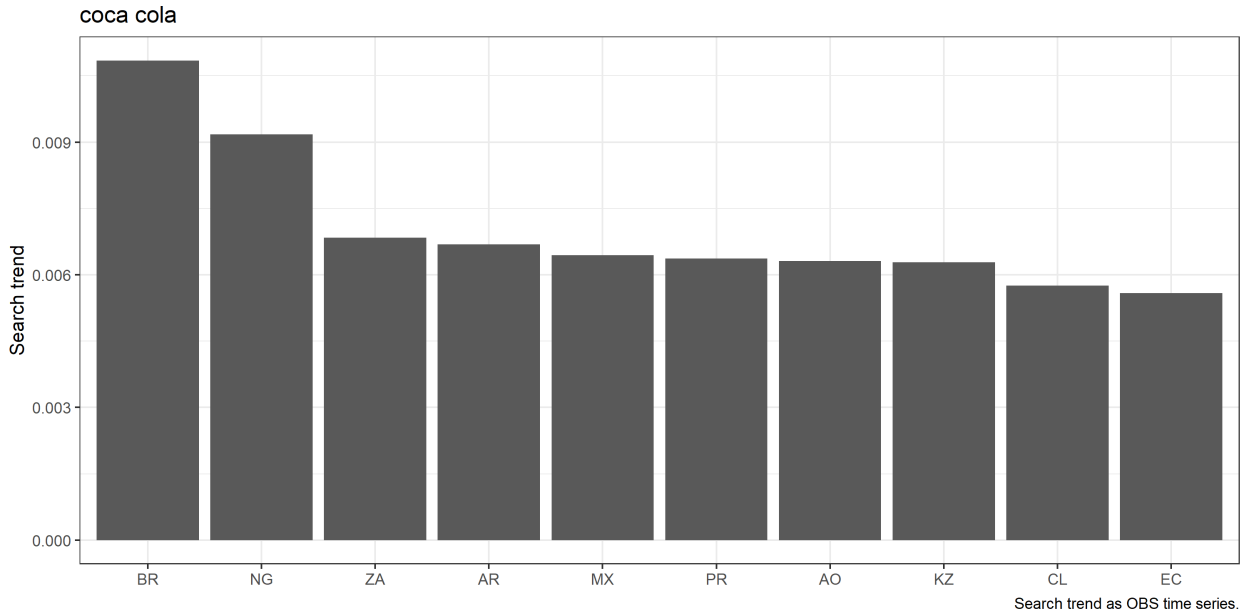
The export functions from `globaltrends` also allow direct interaction with `dplyr` or other packages for further analysis.

```
library(dplyr)

export_doi(object = 1, control = 1, type = "obs") %>%
  filter(lubridate::year(date) == 2019) %>%
  group_by(keyword) %>%
  summarise(gini = mean(gini), .groups = "drop")

#> # A tibble: 3 x 2
#>   keyword    gini
#>   <chr>     <dbl>
#> 1 coca cola 0.615
#> 2 facebook  0.707
#> 3 microsoft 0.682
```

Exports from `globaltrends` serve as input for the plot functions implemented in the package. `plot_score` uses the output from `export_score` as input and shows the locations with the highest search scores. The function uses only the first keyword in the dataset and averages the search scores for the input dataset – we therefore suggest filtering the output from `export_score` to a specific period. The plot shows that Coca-Cola has high search scores across Latin America and India.

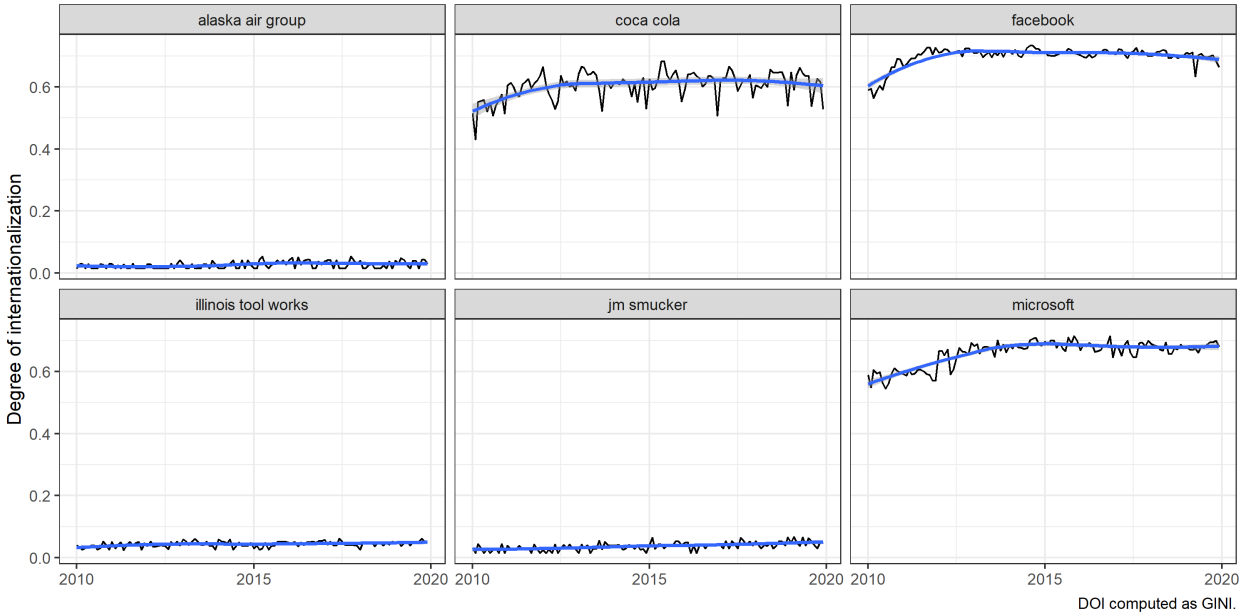
```
library(dplyr)
```

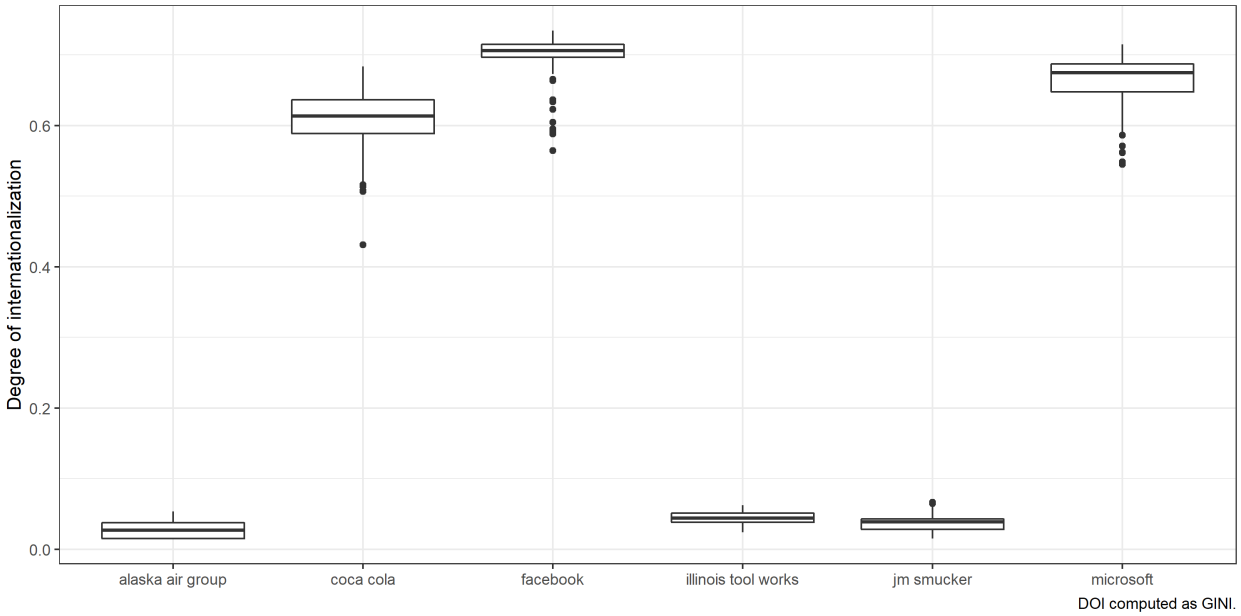
```
export_score(keyword = "coca cola", control = 1) %>%
  filter(lubridate::year(date) == 2019) %>%
  plot_score()
```



The functions `plot_voi_ts`, `plot_doi_ts`, `plot_voi_box`, and `plot_doi_box` use output from `export_voi` and `export_doi`, respectively. The two time series plots `plot_voi_ts` and `plot_doi_ts` show how the volume and degree of internationalization for objects of interest develops over time. The functions `plot_voi_box` and `plot_doi_box` generate boxplots of the volume and degree of internationalization distribution. The four plots below compare the volume and degree of internationalization for the six companies in our sample. At first glance, we see that Coca-Cola, Facebook, and Microsoft have higher degrees of internationalization than Alaska Air Group, Illinois Tool Works, and J.M. Smucker. It seems as if the degree of internationalization of Facebook and Microsoft increased slightly from 2010 to 2015. Although the overall trend remains stable, Coca-Cola shows greater within-time series variation than the other companies.

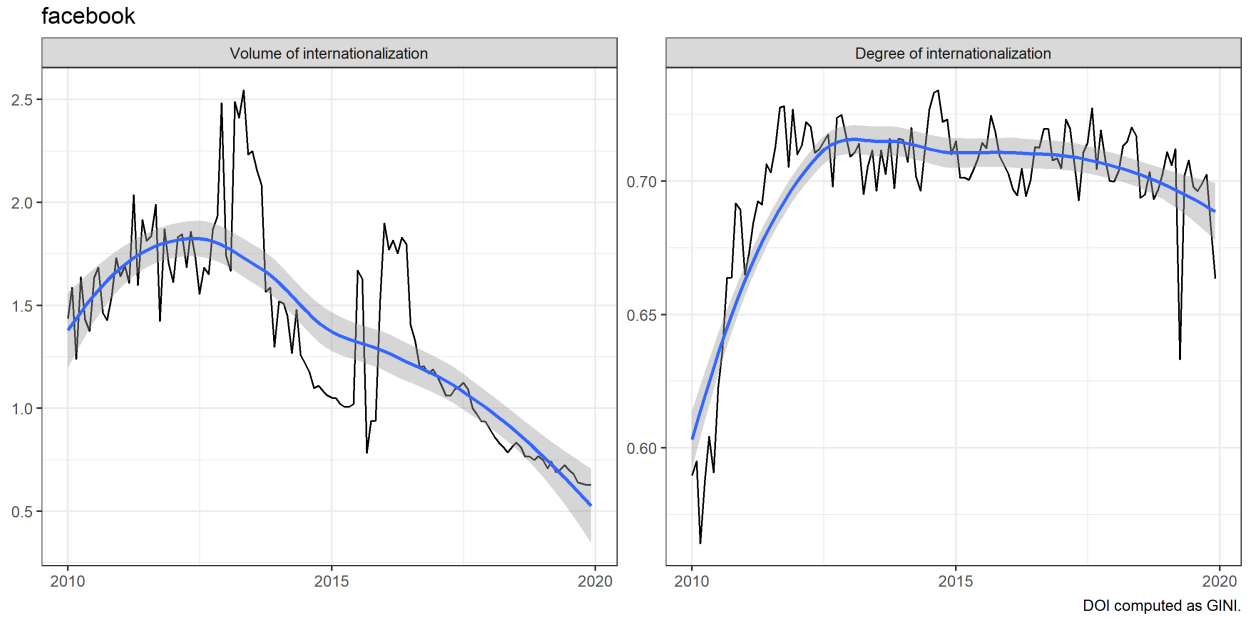
```
data <- purrr::map_dfr(1:2, export_doi, keyword = NULL, control = 1, type = "obs")
plot_ts(data_doi = data, grid = TRUE, smooth = TRUE)

plot_box(data_doi = data)
```





With the function `plot_voi_doi`, users can compare the volume of internationalization for an object of interest to its degree of internationalization. Like `plot_score`, the function uses only the first keyword in a dataset, filtering might be necessary. In the plot below, we compare Facebook's volume of internationalization to its degree of internationalization. While volume of internationalization indicates the level of global search scores, degree of internationalization relates to the global distribution of search scores. We see that Facebook's volume of internationalization constantly decreased after its peak in 2013. At the same time, we observe that the degree of internationalization grew from 2010 before peaking in 2013.

```
out_doi <- export_doi(keyword = "facebook", object = 1, type = "obs")
out_global <- export_global(keyword = "facebook", type = "obs")
plot_trend(data_doi = out_doi, data_global = out_global)
```



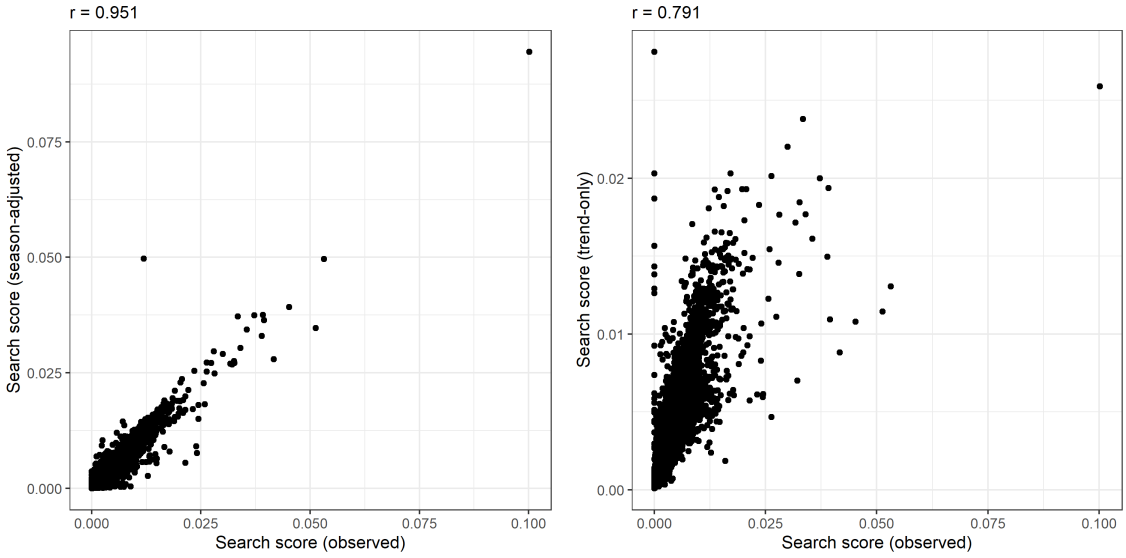
Additional options

The `globaltrends` package offers several options that allow robustness checks and adjustments to the computations. Users can compute global trend dispersion based on different types of time series, use other measures than the inverted Gini-coefficient, or change the set of locations.

Time series adjustments

The computation of search scores in the `globaltrends` package compares a time series of search volumes for an object keyword to the time series of base line search volumes. Noise and seasonality in search volume time series could affect the resulting search scores. The `globaltrends` package offers two time series adjustments as robustness checks. In the `data_score` table, column `score_obs` refers to values without adjustment. Column `score_trd` uses the underlying time series' trend for computation. Column `score_sad` corrects the time series for seasonal patterns. In general, outcomes for all three types of time series are similar. `score_trd` applies the greatest smoothing, while `score_sad` reduces some noise.

```
# computation seasonally adjusted ------------------------------------------------
search_score <- ts(data$hits, frequency = 12)
fit <- stl(search_score, s.window = "period")
trend <- fit$time.series[, "trend"]

# computation trend only ---------------------------------------------------------
search_score <- ts(data$hits, frequency = 12)
fit <- stl(search_score, s.window = "period")
seasad <- forecast::seasadj(fit)
```



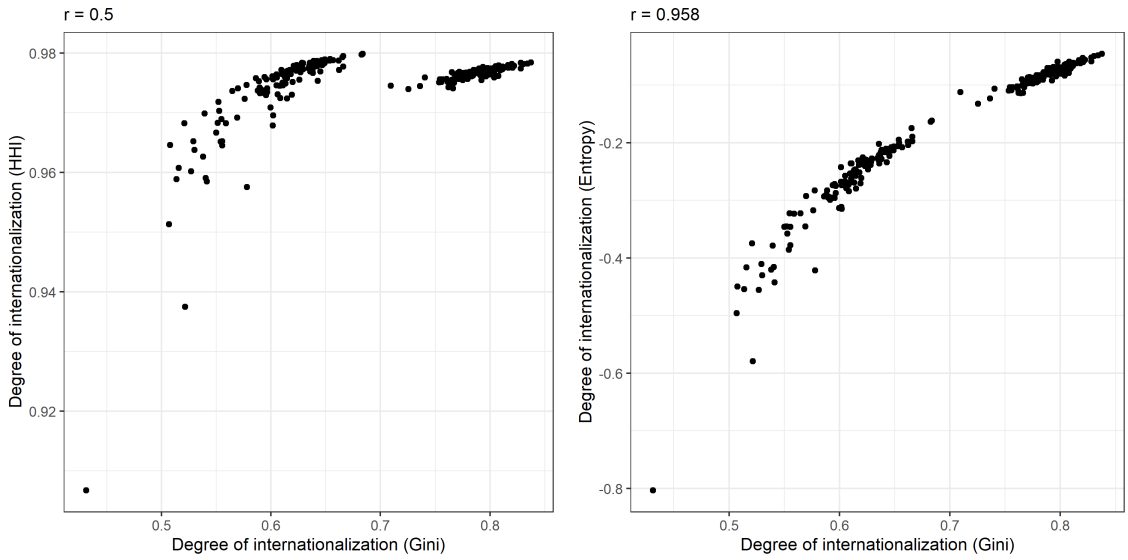
The `export_doi`, `plot_voi_ts`, `plot_doi_ts`, `plot_voi_box`, `plot_doi_box`, and `plot_voi_doi` functions allow filtering for the type of time series through the `type` input.

```
export_doi(keyword, type = "obs")
plot_ts(data_doi, type = "sad")
plot_box(data_doi, type = "trd")
plot_trend(data_doi, data_global, type = "obs")
```

Alternative dispersion measures

The `globaltrends` package computes degree of internationalization based on the across-location distribution of search scores. By default, the package uses an inverted Gini-coefficient. As alternatives, the package uses inverted Herfindahl index and inverted Entropy as robustness checks. In general, all the three dispersion measures come to similar results.

```
# computation inverted ginig coefficient ---------------------------------------
dplyr::coalesce(1 - ineq::ineq(search_score, type = "Gini"), 0)

# computation inverted herfindahl index ----------------------------------------
dplyr::coalesce(1 - sum((search_score / sum(search_score))^2), 0)

# computation inverted entropy -------------------------------------------------
dplyr::coalesce(-1 * ineq::ineq(search_score, parameter = 1, type = "entropy"), 0)
```



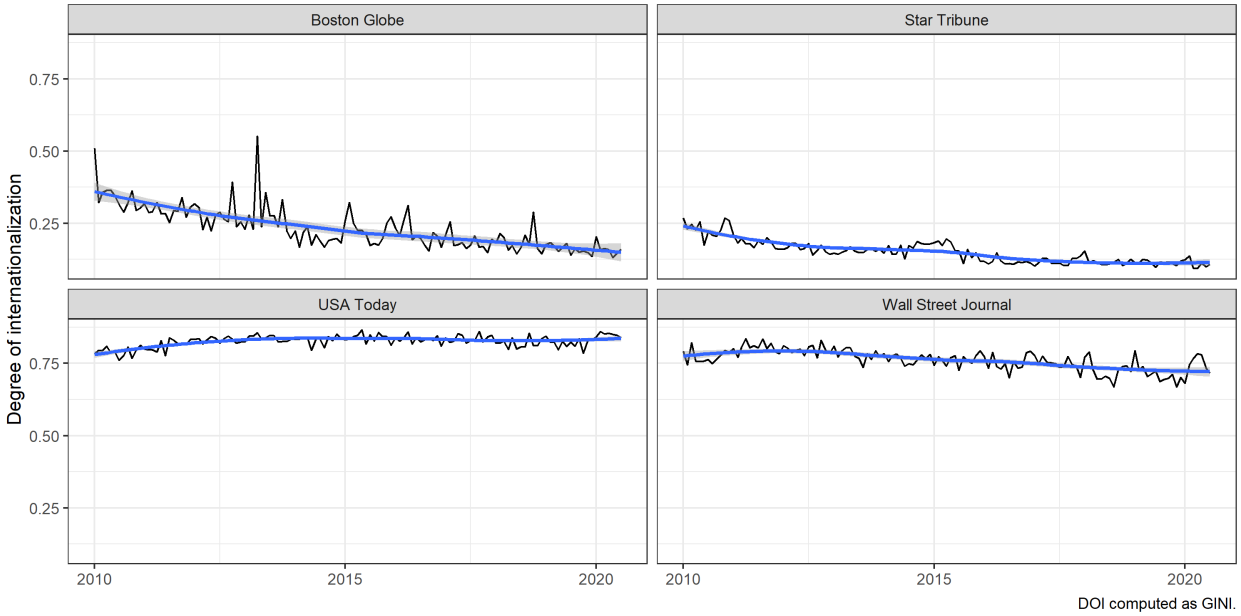
The `export_doi`, `plot_doi_ts`, `plot_doi_box`, and `plot_voi_doi` functions allow filtering for the type of dispersion measures through the `measure` input.

```
export_doi(keyword, measure = "gini")
plot_ts(data_doi, measure = "hhi")
plot_box(data_doi, measure = "entropy")
plot_trend(data_doi, data_global, measure = "gini")
```

Alternative sets of locations

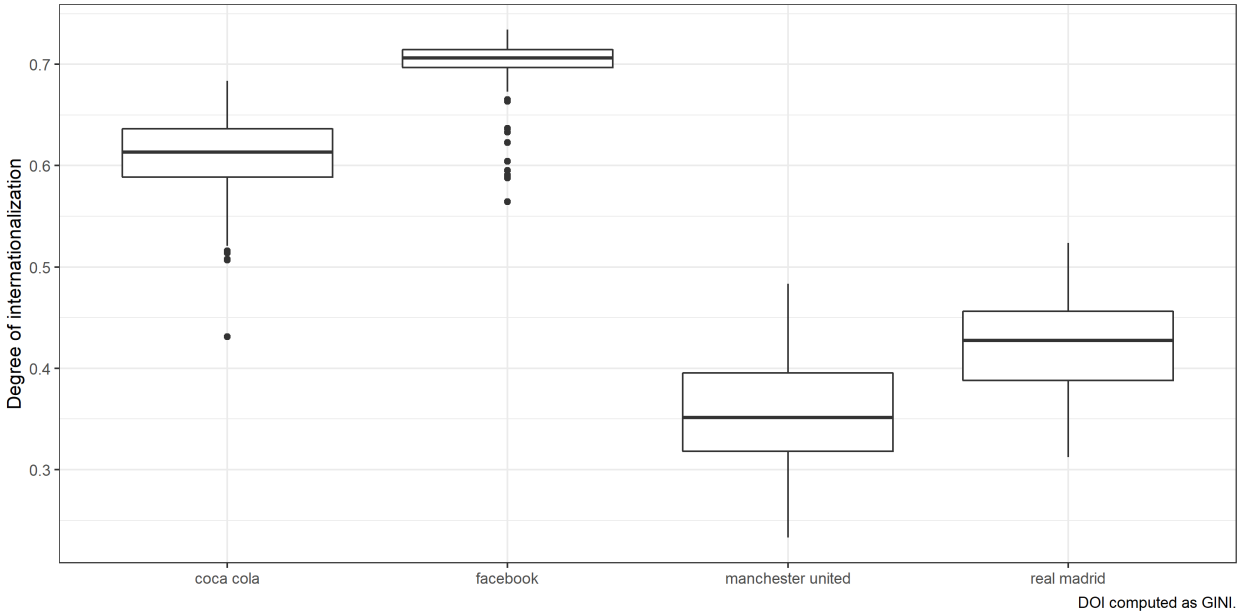
By default, `globaltrends` makes all downloads and computations for the *countries* set of locations. The *countries* set covers all countries that generated at least 0.1% of world GDP in 2018. By changing the input `locations` to *us_states*, the package uses US states and Washington DC as basis for downloads and computations instead. Apart from `compute_doi`, all functions use either *countries* or *us_states* as inputs for `locations`. `start_db` exports these vectors of ISO2 codes to the global environment. `compute_doi`, however does not directly refer to these objects, but to their names: `locations = "countries"` or `locations = "us_states"`. Using state or district level locations allows users to analyze within-country dispersion of firms.

```
download_control(control = 1, locations = us_states)
download_object(object = list(1,2), locations = us_states)
download_mapping(control = 1, object = 2, locations = us_states)
compute_score(control = 1, object = 2, locations = us_states)
compute_doi(control = 1, object = list(1,2), locations = "us_states")
```



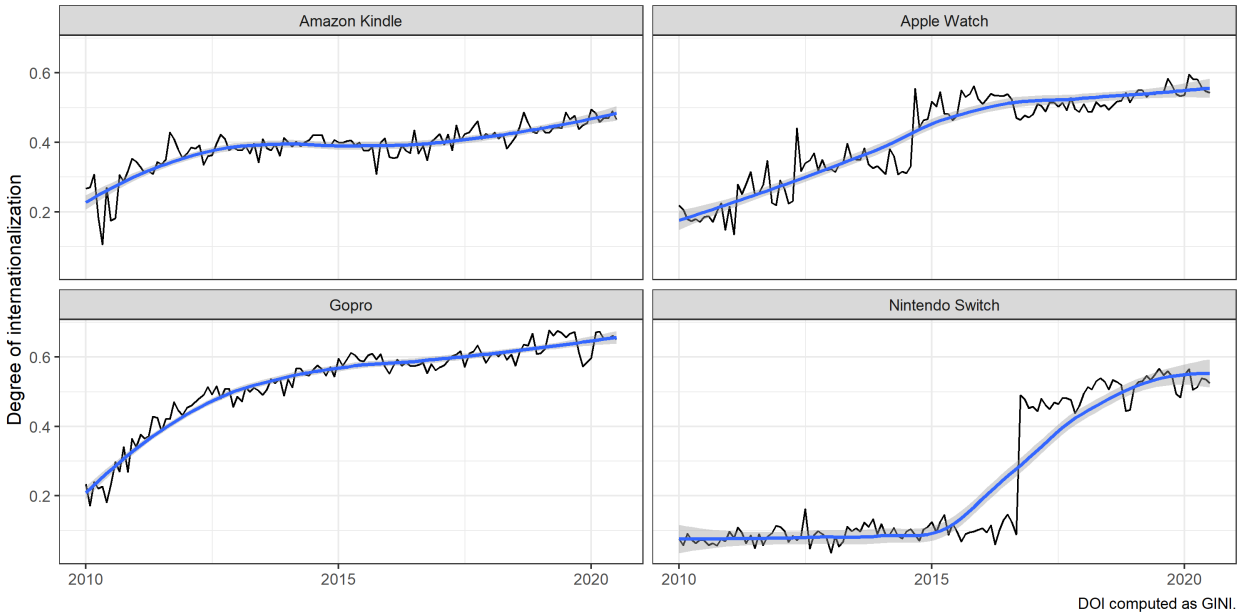
Further applications

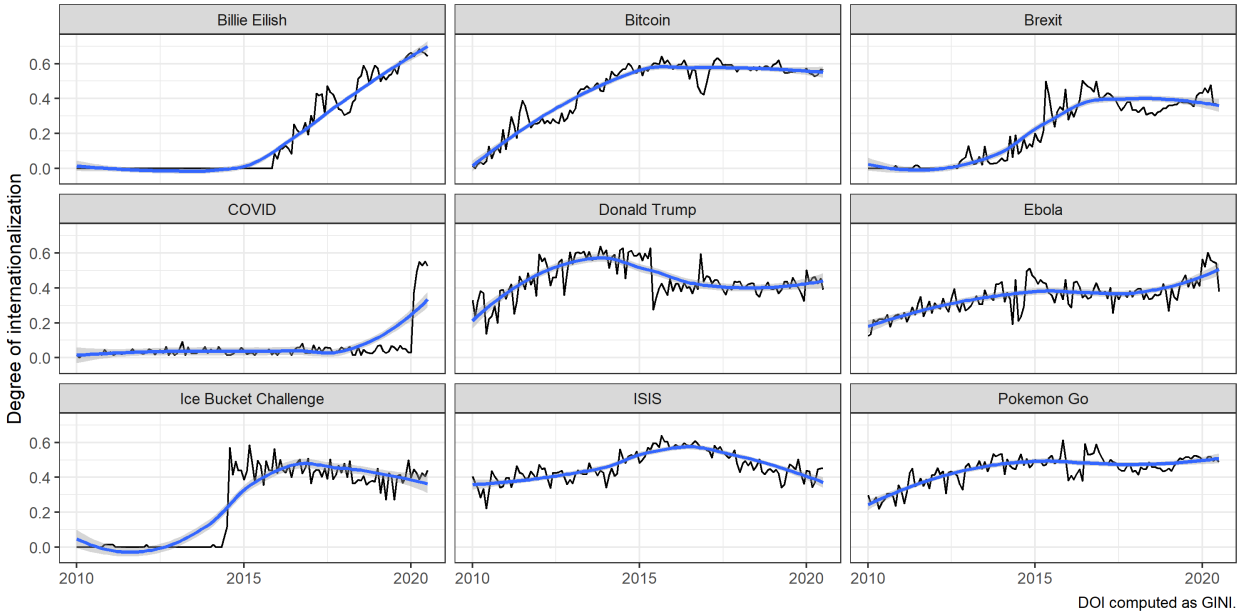
To measure degree of internationalization, `globaltrends` offers a wide array of empirical possibilities. It allows researchers to compare degree of internationalization for various organizations on a unified scale (e.g. *Coca-Cola Company*, *Facebook Inc.*, *Real Madrid*, and *Manchester United*). In addition, the time-series nature of Google Trends allows for historical analysis of internationalization patterns and speed within organizations.

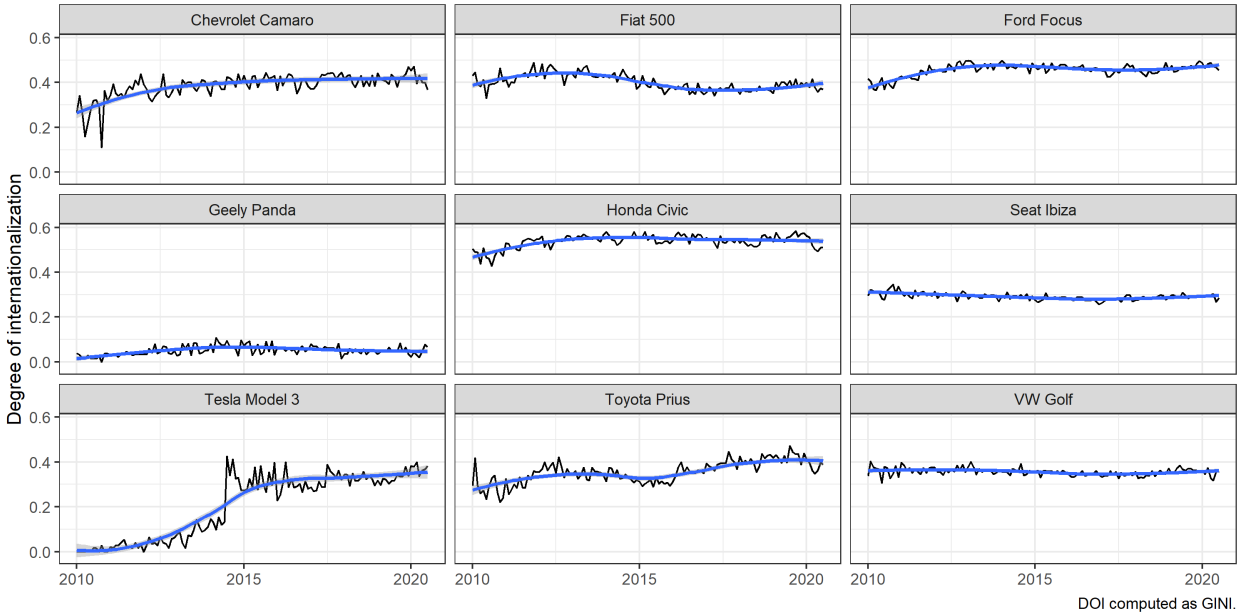


The enormous detail of the data opens additional applications in research that are impossible with traditional measures of internationalization. For instance, using `globaltrends` on a subnational level (e.g. `locations = us_states`) allows researchers to study proliferation within a country and, for example, to trace a particular

market entry. In addition, `globaltrends` offers applications beyond corporate internationalization, such as data on global interest in products, persons, events, fads or scandals.







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