task2

data cleaning

```
## Warning in FUN(X[[i]], ...): strings not representable in native encoding will
## be translated to UTF-8
```

```
## Warning: Missing column names filled in: 'X1' [1]
```

```
## Parsed with column specification:
## cols(
##   X1 = col_double(),
##   country_region = col_character(),
##   a_value = col_double(),
##   b_value = col_double(),
##   c_value = col_double()
## )
```

```
## [1] 27
```

```
##  [1] Belarus             Brunei              Cambodia
##  [4] China               Denmark             Estonia
##  [7] Guatemala           Honduras            Iran
## [10] Jamaica             Japan               Kazakhstan
## [13] Korea, South        Liechtenstein       Norway
## [16] Pakistan            Peru                Qatar
## [19] San Marino          Slovakia            Slovenia
## [22] Sri Lanka           Sweden              Trinidad and Tobago
## [25] Uruguay             Uzbekistan          Venezuela
## 116 Levels: Afghanistan Albania Algeria Andorra Argentina Armenia ... Vietnam
```

```
##    country_region b_value
## 96      Singapore   0.085
```

```
##          country_region b_value
## 106 Trinidad and Tobago   3.857
```

predict data

```
## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
```

```
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )
## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )
## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )

## Parsed with column specification:
## cols(
##   FIPS = col_double(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_character(),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
```

```
## )
## Parsed with column specification:
## cols(
##   FIPS = col_double(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_character(),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
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##   Country_Region = col_character(),
##   Last_Update = col_character(),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )

## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )
## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
```

```
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )

## Parsed with column specification:
## cols(
##   FIPS = col_double(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_character(),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )

## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )

## Parsed with column specification:
## cols(
##   FIPS = col_double(),
##   Admin2 = col_character(),
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##   Country_Region = col_character(),
##   Last_Update = col_character(),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
```

```
##   Active = col_double(),
##   Combined_Key = col_character()
## )
```

```
## Parsed with column specification:
## cols(
##   FIPS = col_character(),
##   Admin2 = col_character(),
##   Province_State = col_character(),
##   Country_Region = col_character(),
##   Last_Update = col_datetime(format = ""),
##   Lat = col_double(),
##   Long_ = col_double(),
##   Confirmed = col_double(),
##   Deaths = col_double(),
##   Recovered = col_double(),
##   Active = col_double(),
##   Combined_Key = col_character()
## )
```

	.
Afghanistan	3.200053e+03
China	1.211702e+07
Korea_South	9.565317e+05
United_Kingdom	2.690240e+08
US	1.428445e+10
Vietnam	8.978671e+01

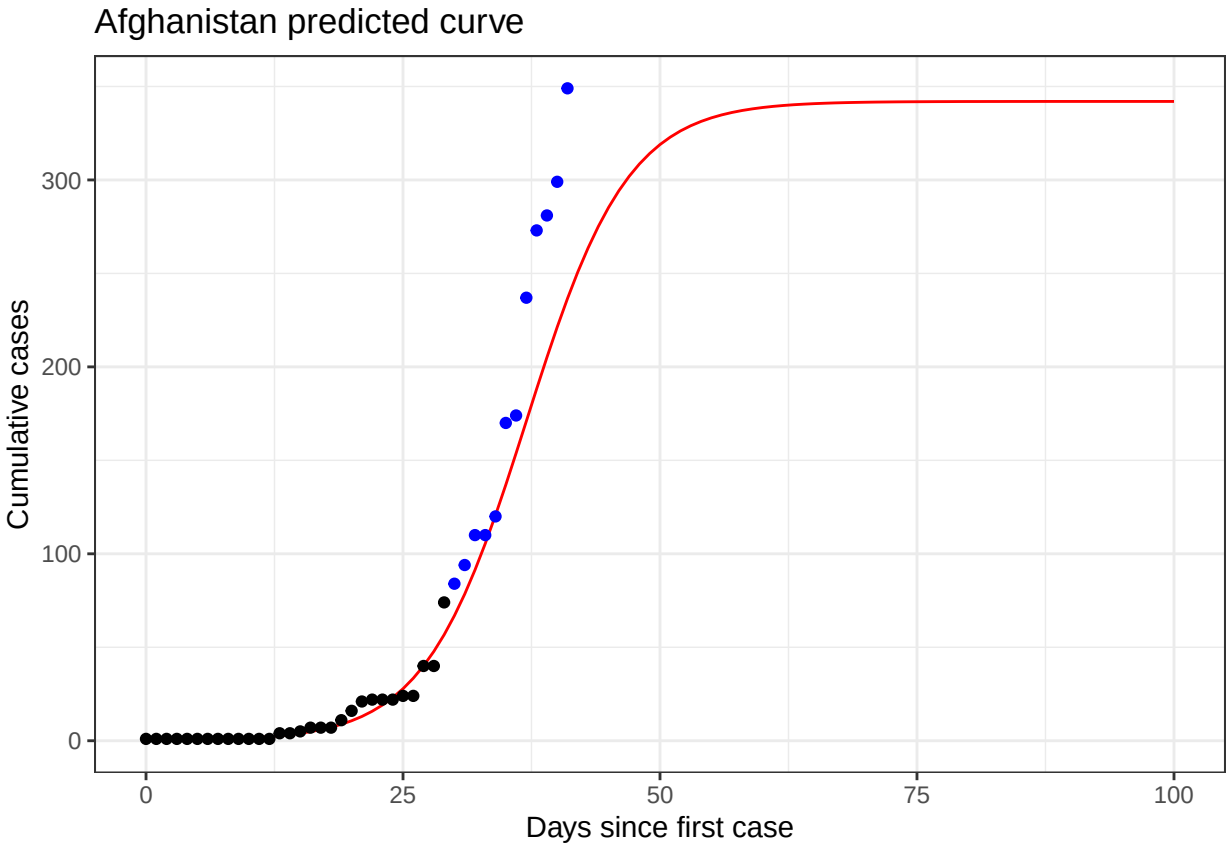
country_region	a_value	b_value	c_value
Afghanistan	342	0.202	37
Albania	269	0.173	17
Algeria	723	0.258	30
Andorra	345	0.344	22
Argentina	970	0.315	23
Armenia	514	0.288	23
Australia	4072	0.293	58
Austria	10760	0.275	28
Azerbaijan	365	0.184	30
Bahrain	795	0.118	29
Bangladesh	99	0.244	18
Belarus	102	0.276	19
Belgium	8530	0.254	49
Bolivia	81	0.192	16
Bosnia and Herzegovina	352	0.292	19
Brazil	4507	0.380	27
Brunei	98	0.381	7
Bulgaria	459	0.253	16
Burkina Faso	252	0.363	14
Cambodia	168	0.317	56
Canada	5462	0.338	58
Chile	1862	0.318	21

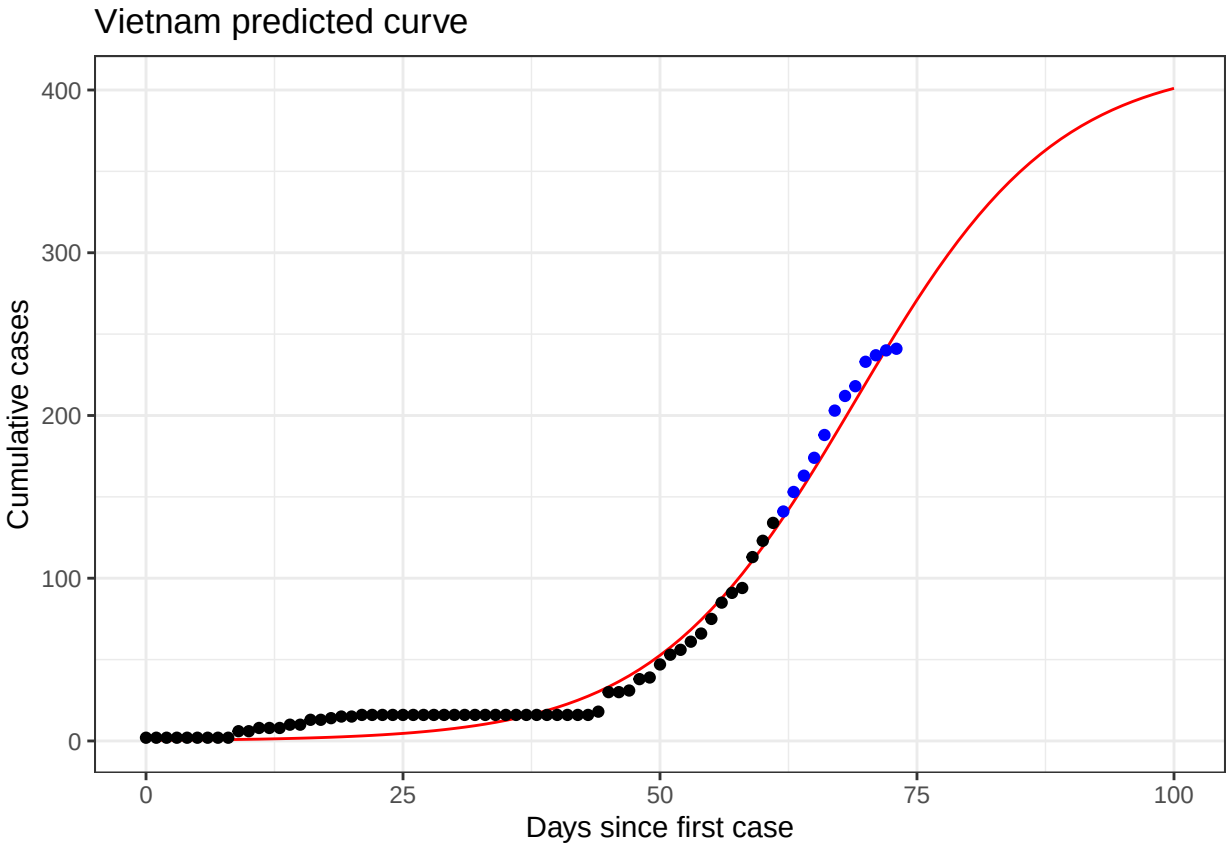
country_region	a_value	b_value	c_value
China	78732	0.223	18
Colombia	777	0.335	18
Congo (Kinshasa)	115	0.360	14
Costa Rica	375	0.268	18
Cote d'Ivoire	342	0.857	15
Croatia	958	0.310	29
Cuba	122	0.363	13
Cyprus	272	0.234	15
Denmark	3258	0.170	24
Dominican Republic	640	0.498	23
Ecuador	2180	0.449	23
Egypt	806	0.193	39
Estonia	569	0.235	22
Finland	1570	0.216	55
France	39932	0.148	64
Georgia	151	0.140	29
Germany	65957	0.259	57
Ghana	300	0.332	15
Greece	1499	0.182	27
Guatemala	23	0.589	6
Honduras	32	0.549	8
Hungary	393	0.266	20
Iceland	1311	0.213	25
India	1060	0.253	54
Indonesia	1389	0.266	22
Iran	49441	0.131	33
Iraq	642	0.143	30
Ireland	2673	0.309	24
Israel	4055	0.304	33
Italy	138340	0.183	53
Jamaica	20	0.331	5
Japan	2195	0.094	60
Jordan	326	0.302	21
Kazakhstan	69	0.529	5
Kenya	237	0.320	18
Korea, South	8801	0.284	40
Kuwait	564	0.088	36
Kyrgyzstan	279	0.546	9
Latvia	411	0.270	22
Lebanon	829	0.169	35
Liechtenstein	55	0.500	15
Lithuania	432	0.451	25
Luxembourg	2213	0.354	24
Malaysia	3231	0.222	59
Malta	242	0.248	17
Martinique	135	0.251	18
Mauritius	115	0.492	7
Mexico	748	0.317	25
Moldova	273	0.285	16
Monaco	60	0.272	25
Montenegro	124	0.507	8
Morocco	357	0.291	22

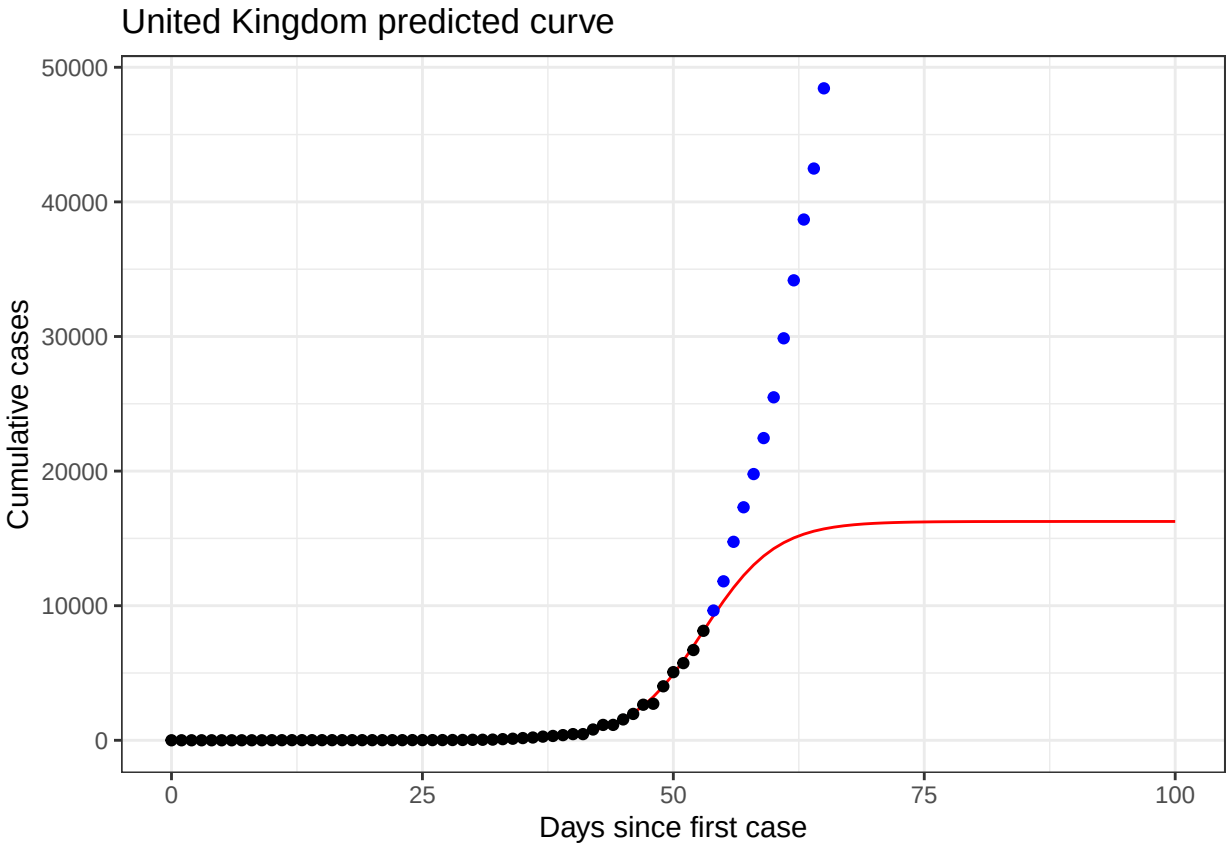
country_region	a_value	b_value	c_value
Netherlands	11170	0.239	26
New Zealand	505	0.420	27
Nigeria	102	0.407	25
North Macedonia	309	0.325	27
Norway	5557	0.175	26
Oman	361	0.125	40
Pakistan	1774	0.326	26
Panama	715	0.321	14
Paraguay	74	0.195	19
Peru	678	0.322	16
Philippines	1091	0.240	54
Poland	1821	0.283	20
Portugal	4741	0.335	22
Qatar	889	0.175	19
Romania	1783	0.256	29
Russia	979	0.291	53
Rwanda	107	0.356	11
San Marino	230	0.191	19
Saudi Arabia	1551	0.288	23
Senegal	357	0.217	27
Serbia	627	0.286	18
Singapore	1262	0.085	67
Slovakia	254	0.332	13
Slovenia	805	0.200	16
South Africa	1303	0.343	20
Spain	79759	0.257	52
Sri Lanka	105	0.459	51
Sweden	4381	0.171	52
Switzerland	19766	0.261	28
Taiwan*	576	0.097	70
Thailand	1634	0.306	62
Trinidad and Tobago	53	3.857	6
Tunisia	419	0.242	24
Turkey	3770	0.537	13
Ukraine	212	0.395	21
United Arab Emirates	652	0.114	62
United Kingdom	16258	0.279	53
Uruguay	184	0.548	6
US	106991	0.389	29
Uzbekistan	50	0.729	4
Venezuela	95	0.426	5
Vietnam	418	0.102	69

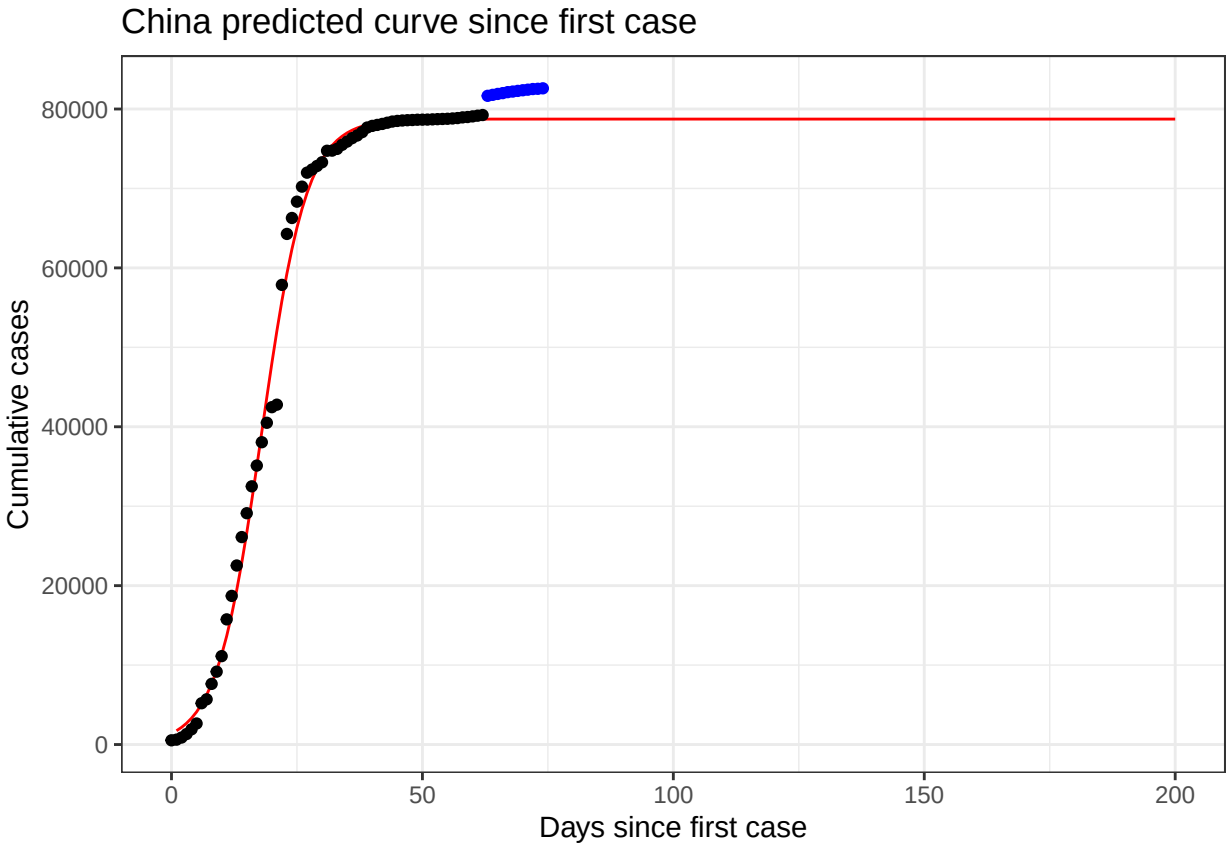
Plot some country

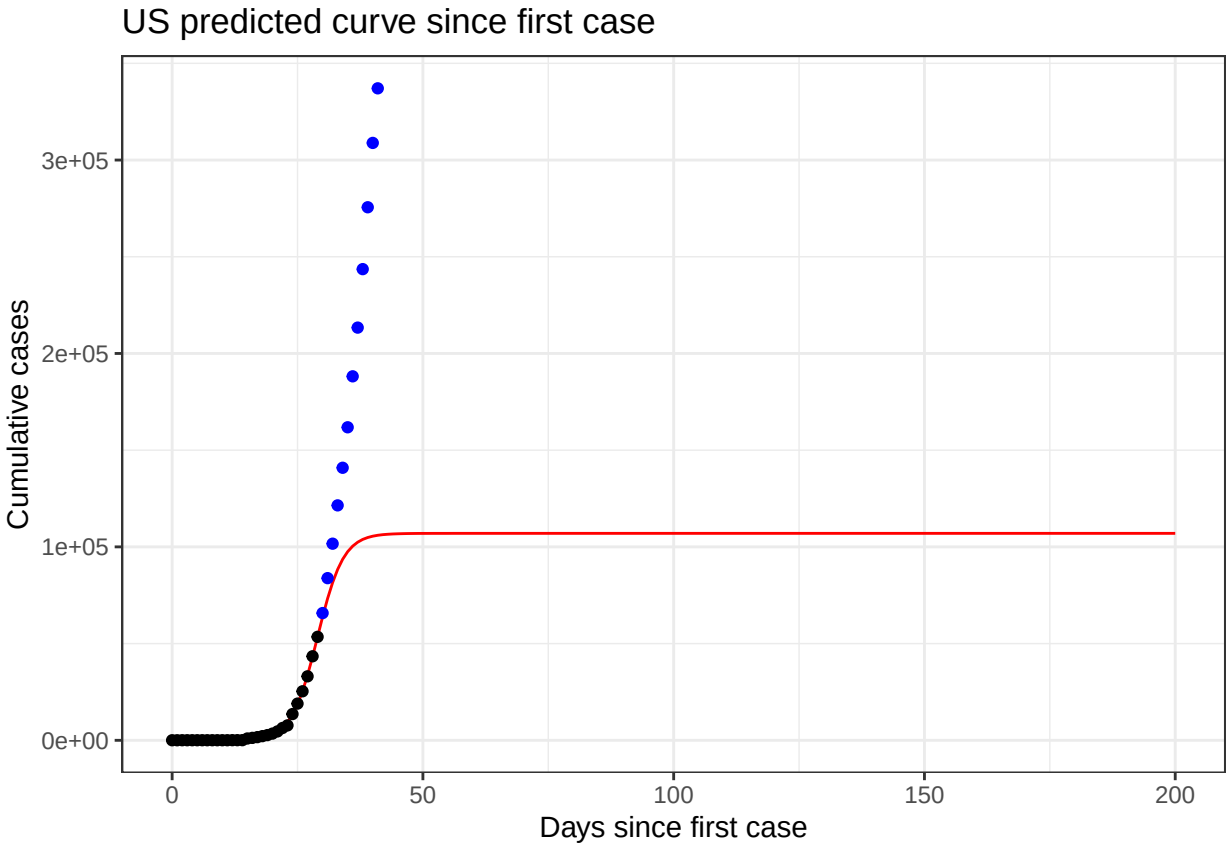
```
## Warning: `as.tibble()` is deprecated as of tibble 2.0.0.
## Please use `as_tibble()` instead.
## The signature and semantics have changed, see `?as_tibble`.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_warnings()` to see where this warning was generated.
```

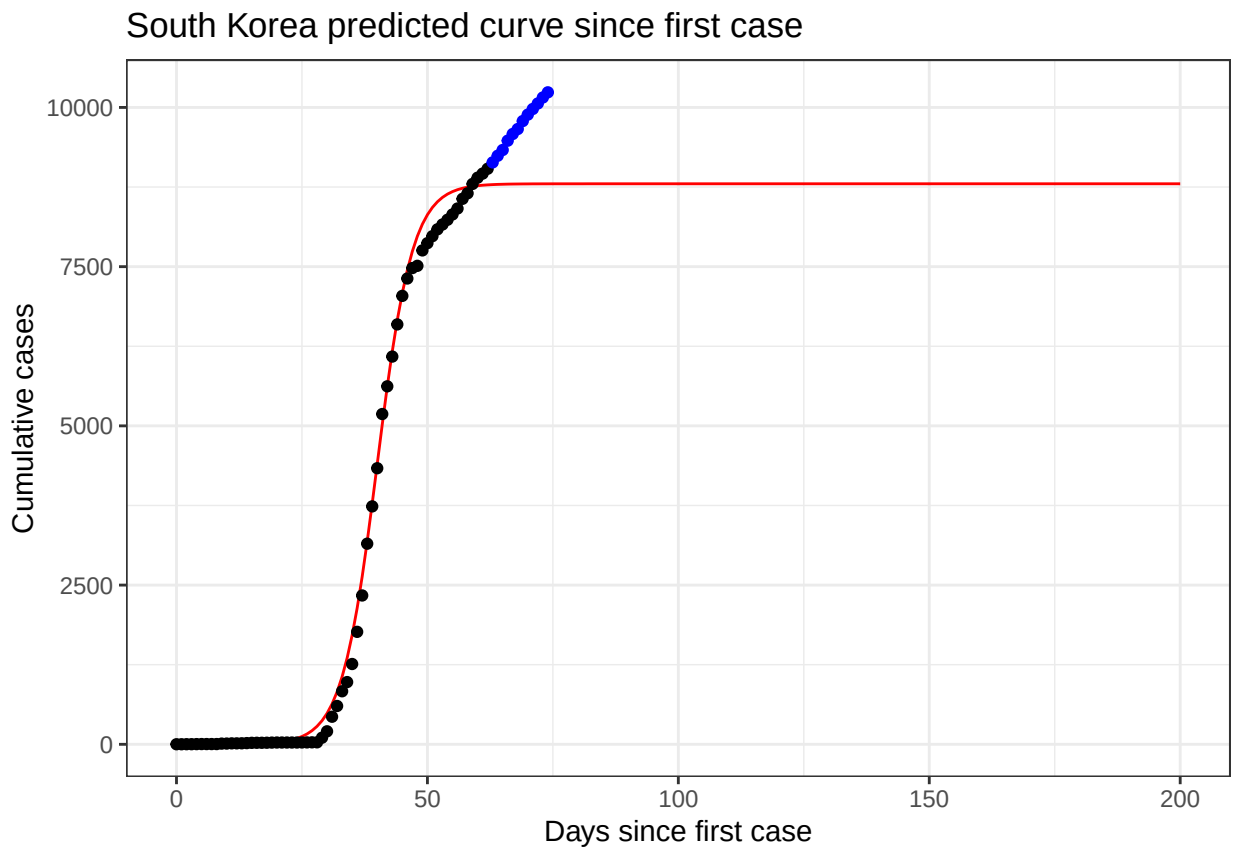

Afghanistan predicted curve
Cumulative cases
300
200
100
0
0
25
50
75
100
Days since first case


Vietnam predicted curve
Cumulative cases
400
300
200
100
0
0
25
50
75
100
Days since first case


United Kingdom predicted curve
Cumulative cases
50000
40000
30000
20000
10000
0
0
25
50
75
100
Days since first case


China predicted curve since first case
Cumulative cases
80000
60000
40000
20000
0
0
50
100
150
200
Days since first case


US predicted curve since first case
Cumulative cases
3e+05
2e+05
1e+05
0e+00
0
50
100
150
200
Days since first case



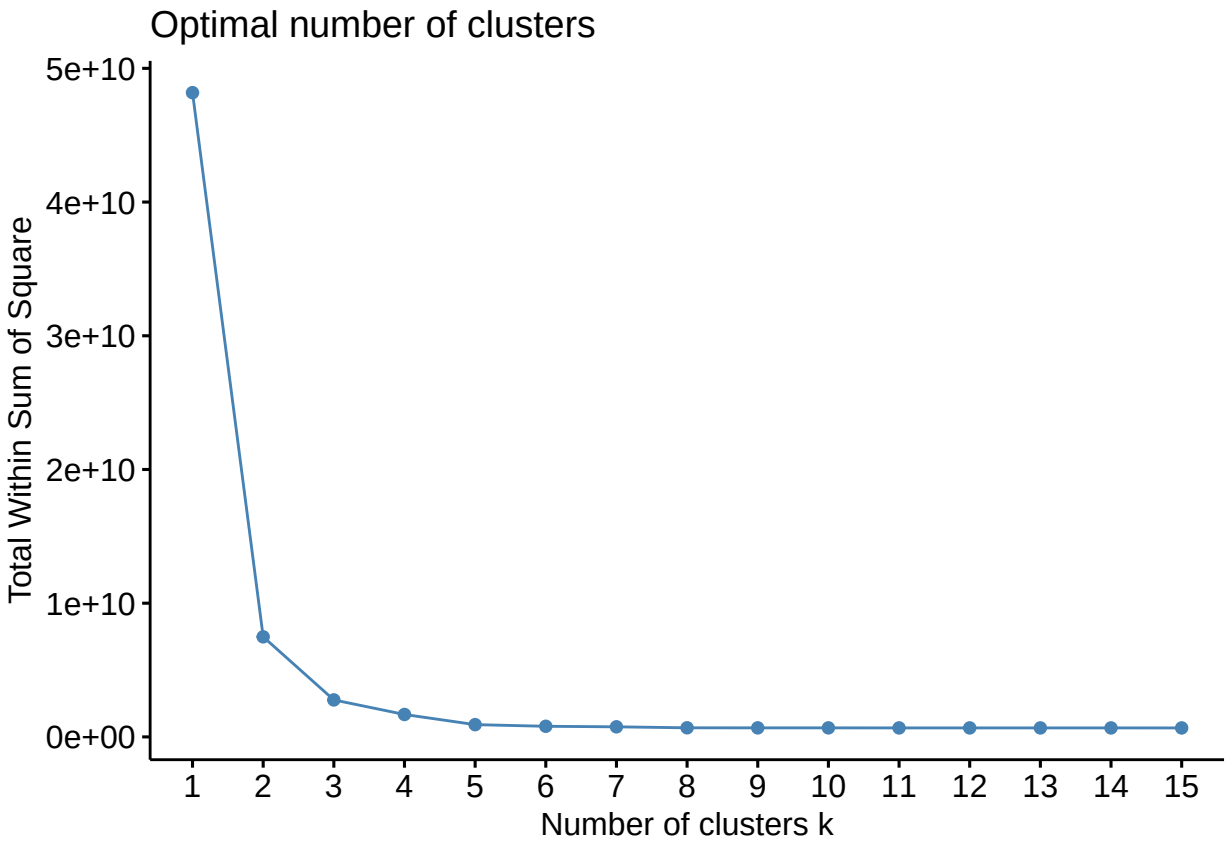
Country	Train_error
Afghanistan	2.080206e+01
China	4.077602e+06
Korea_South	4.471121e+04
United_Kingdom	9.472004e+03
US	1.871744e+05
Vietnam	5.664849e+01

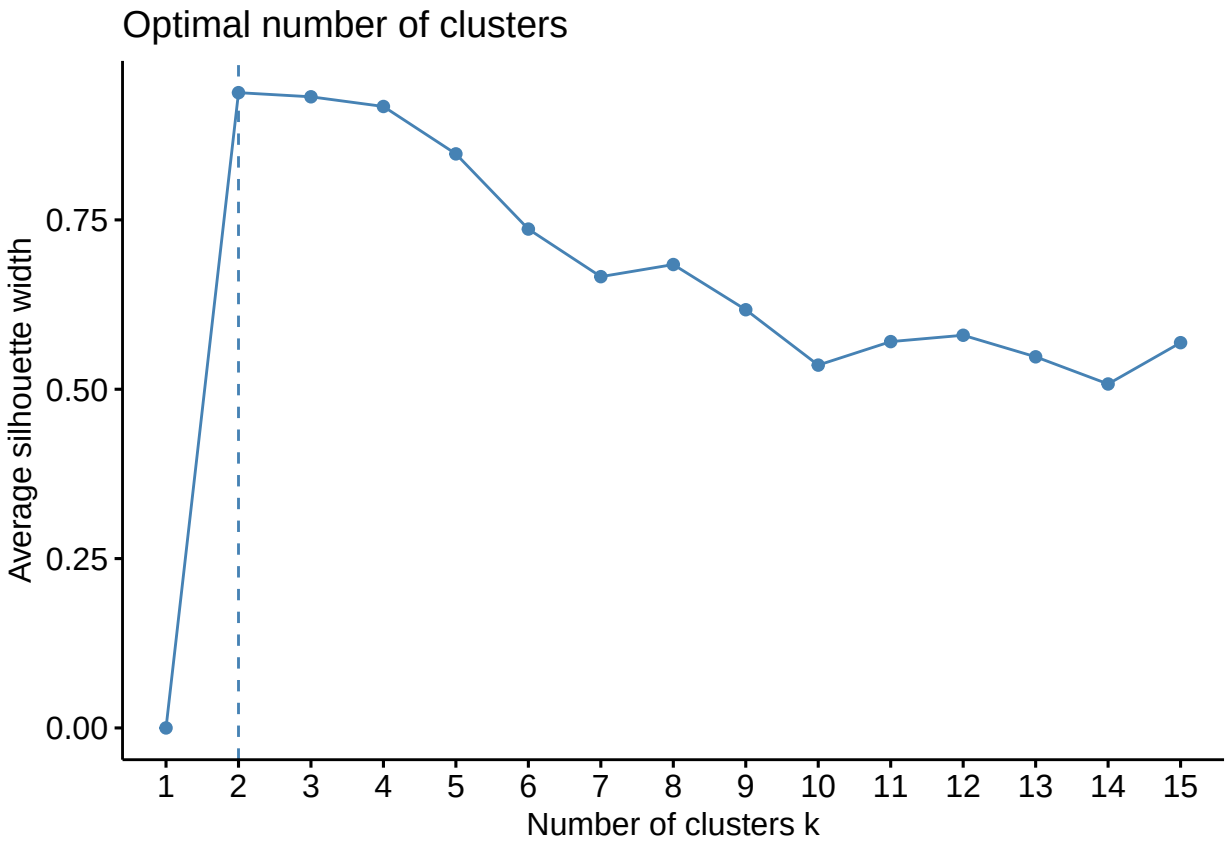
Country	test_error
Afghanistan	3.200053e+03
China	1.211702e+07
Korea_South	9.565317e+05
United_Kingdom	2.690240e+08
US	1.428445e+10
Vietnam	8.978671e+01

Task2

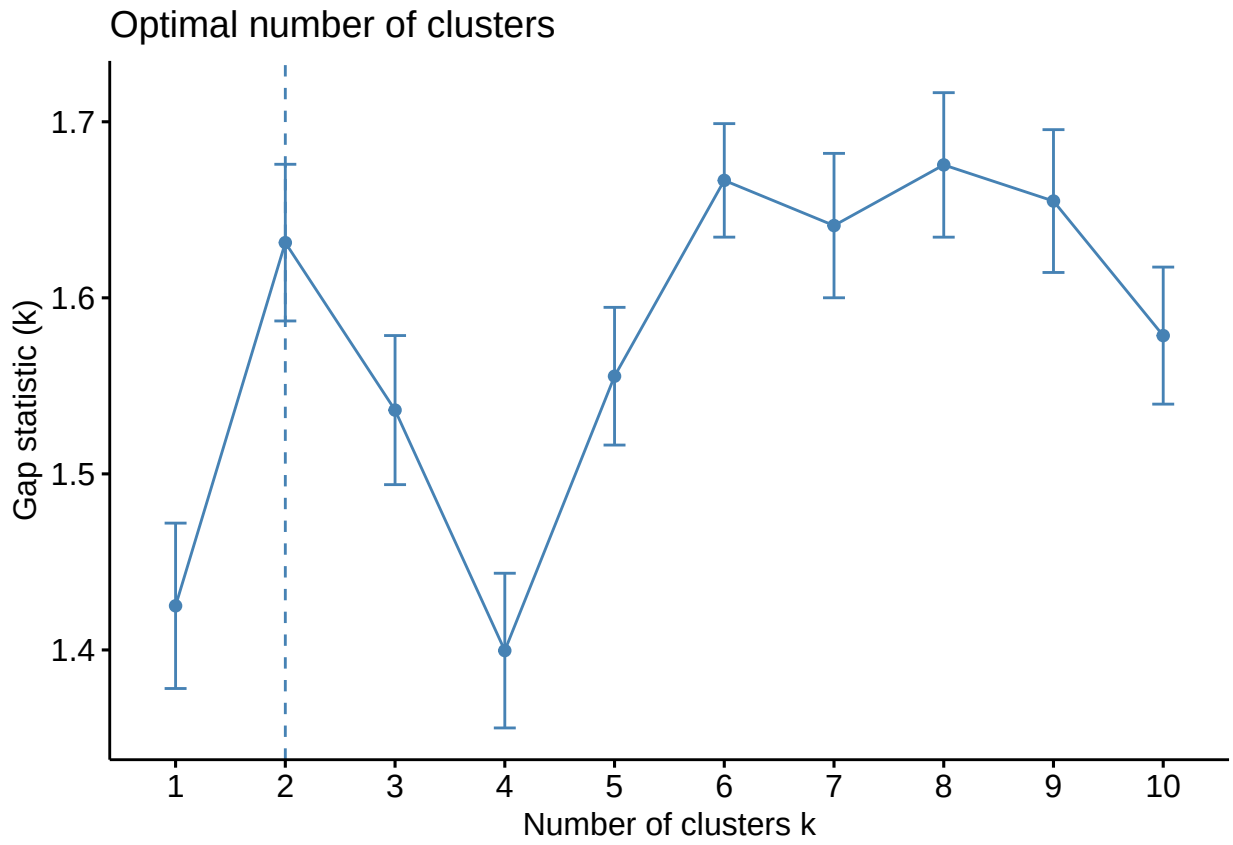
```
## Warning: package 'factoextra' was built under R version 3.6.3
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```


Optimal number of clusters
Total Within Sum of Square
5e+10
4e+10
3e+10
2e+10
1e+10
0e+00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Number of clusters k




```
## Warning: package 'cluster' was built under R version 3.6.3
```




```
## [1] 4.209700e+10 1.411247e+01 1.883796e+04
```

```
## [1] 7.485164e+09 1.441893e+01 3.048189e+04
```

```
## $`1`
##     a_value b_value c_value cluster country
## 23    78732   0.223      18       1   China
## 39    65957   0.259      57       1 Germany
## 48    49441   0.131      33       1    Iran
## 52   138340   0.183      53       1   Italy
## 100   79759   0.257      52       1   Spain
## 113  106991   0.389      29       1      US
##
## $`2`
##     a_value b_value c_value cluster              country
## 1       342   0.202      37       2          Afghanistan
## 2       269   0.173      17       2              Albania
## 3       723   0.258      30       2              Algeria
## 4       345   0.344      22       2              Andorra
## 5       970   0.315      23       2            Argentina
## 6       514   0.288      23       2              Armenia
## 7      4072   0.293      58       2            Australia
## 8     10760   0.275      28       2              Austria
## 9       365   0.184      30       2           Azerbaijan
## 10      795   0.118      29       2              Bahrain
```

```
## 11       99   0.244      18       2             Bangladesh
## 12      102   0.276      19       2                Belarus
## 13     8530   0.254      49       2                Belgium
## 14       81   0.192      16       2                Bolivia
## 15      352   0.292      19       2 Bosnia and Herzegovina
## 16     4507   0.380      27       2                 Brazil
## 17       98   0.381       7       2                 Brunei
## 18      459   0.253      16       2               Bulgaria
## 19      252   0.363      14       2           Burkina Faso
## 20      168   0.317      56       2               Cambodia
## 21     5462   0.338      58       2                 Canada
## 22     1862   0.318      21       2                  Chile
## 24      777   0.335      18       2               Colombia
## 25      115   0.360      14       2       Congo (Kinshasa)
## 26      375   0.268      18       2             Costa Rica
## 27      342   0.857      15       2          Cote d'Ivoire
## 28      958   0.310      29       2                Croatia
## 29      122   0.363      13       2                   Cuba
## 30      272   0.234      15       2                 Cyprus
## 31     3258   0.170      24       2                Denmark
## 32      640   0.498      23       2     Dominican Republic
## 33     2180   0.449      23       2                Ecuador
## 34      806   0.193      39       2                  Egypt
## 35      569   0.235      22       2                Estonia
## 36     1570   0.216      55       2                Finland
## 37    39932   0.148      64       2                 France
## 38      151   0.140      29       2                Georgia
## 40      300   0.332      15       2                  Ghana
## 41     1499   0.182      27       2                 Greece
## 42       23   0.589       6       2              Guatemala
## 43       32   0.549       8       2               Honduras
## 44      393   0.266      20       2                Hungary
## 45     1311   0.213      25       2                Iceland
## 46     1060   0.253      54       2                  India
## 47     1389   0.266      22       2              Indonesia
## 49      642   0.143      30       2                   Iraq
## 50     2673   0.309      24       2                Ireland
## 51     4055   0.304      33       2                 Israel
## 53       20   0.331       5       2                Jamaica
## 54     2195   0.094      60       2                  Japan
## 55      326   0.302      21       2                 Jordan
## 56       69   0.529       5       2             Kazakhstan
## 57      237   0.320      18       2                  Kenya
## 58     8801   0.284      40       2           Korea, South
## 59      564   0.088      36       2                 Kuwait
## 60      279   0.546       9       2             Kyrgyzstan
## 61      411   0.270      22       2                 Latvia
## 62      829   0.169      35       2                Lebanon
## 63       55   0.500      15       2          Liechtenstein
## 64      432   0.451      25       2              Lithuania
## 65     2213   0.354      24       2             Luxembourg
## 66     3231   0.222      59       2               Malaysia
## 67      242   0.248      17       2                  Malta
## 68      135   0.251      18       2             Martinique
```

```
## 69      115   0.492       7       2              Mauritius
## 70      748   0.317      25       2                 Mexico
## 71      273   0.285      16       2                Moldova
## 72       60   0.272      25       2                 Monaco
## 73      124   0.507       8       2             Montenegro
## 74      357   0.291      22       2                Morocco
## 75    11170   0.239      26       2            Netherlands
## 76      505   0.420      27       2            New Zealand
## 77      102   0.407      25       2                Nigeria
## 78      309   0.325      27       2        North Macedonia
## 79     5557   0.175      26       2                 Norway
## 80      361   0.125      40       2                   Oman
## 81     1774   0.326      26       2               Pakistan
## 82      715   0.321      14       2                 Panama
## 83       74   0.195      19       2               Paraguay
## 84      678   0.322      16       2                   Peru
## 85     1091   0.240      54       2            Philippines
## 86     1821   0.283      20       2                 Poland
## 87     4741   0.335      22       2               Portugal
## 88      889   0.175      19       2                  Qatar
## 89     1783   0.256      29       2                Romania
## 90      979   0.291      53       2                 Russia
## 91      107   0.356      11       2                 Rwanda
## 92      230   0.191      19       2             San Marino
## 93     1551   0.288      23       2           Saudi Arabia
## 94      357   0.217      27       2                Senegal
## 95      627   0.286      18       2                 Serbia
## 96     1262   0.085      67       2              Singapore
## 97      254   0.332      13       2               Slovakia
## 98      805   0.200      16       2               Slovenia
## 99     1303   0.343      20       2           South Africa
## 101     105   0.459      51       2              Sri Lanka
## 102    4381   0.171      52       2                 Sweden
## 103   19766   0.261      28       2            Switzerland
## 104     576   0.097      70       2                Taiwan*
## 105    1634   0.306      62       2               Thailand
## 106      53   3.857       6       2    Trinidad and Tobago
## 107     419   0.242      24       2                Tunisia
## 108    3770   0.537      13       2                 Turkey
## 109     212   0.395      21       2                Ukraine
## 110     652   0.114      62       2   United Arab Emirates
## 111   16258   0.279      53       2         United Kingdom
## 112     184   0.548       6       2                Uruguay
## 114      50   0.729       4       2             Uzbekistan
## 115      95   0.426       5       2              Venezuela
## 116     418   0.102      69       2                Vietnam
```