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Introducing `demstock`: An R Package for Calculating Stock Variables Using the Varieties of Democracy (V-Dem) Data[*]

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Abstract

This working paper introduces the `demstock` package, which allows R users to calculate the stock of virtually any variable made available in the Varieties of Democracy (V-Dem) dataset. Stock represents the weighted cumulative sum of past values, where the weight is an annual depreciation rate specified by the user. The package allows users to calculate the stock of multiple variables at once and with various depreciation rates, supporting face-validity and robustness checks. The `demstock` package therefore provides flexible options for testing theories about historical legacies using a large-N approach that are valuable for democracy research. The package may also assist with qualitative case selection where information about past experience serves as an attribute of interest.

1 Introduction

Scholars are often interested in investigating whether "history matters" in a causal way, i.e. whether past events and experiences explain subsequent ones. For example, research shows that democratic experience helps "make democracy work" by promoting "social capital" (Putnam, Leonardi, and Nanetti 1994) or a "civic culture" (Almond and Verba 1963), engendering a belief that democracy is the "only game in town" (Linz and Stepan 1996). For this reason, Gerring et al. (2005, 325) introduced the concept of democratic stock, arguing that scholars should "consider regimes as historically informed phenomena" because "institutional effects u nfold o ver t ime" a nd h ave c umulative t emporal effects. While numerous studies have used a stock approach to explain various outcomes related to democracy (e.g., Boese et al. 2021; Wigley and Akkoyunlu-Wigley 2011; Pelke 2023; Sato and Wiebrecht 2024), contemporaneous or one-year lags of democracy scores remain the norm for quantitative research.

To facilitate more systematic large-N research on historical legacies, this working paper introduces an R package — `demstock` — which allows users to calculate a stock measure of virtually any variable included in the Varieties of Democracy (V-Dem) dataset (Coppedge et al. 2025a).[1] By stock, we mean a country's accumulated experience rather than its contemporaneous or lagged values for a given indicator or index. Following Gerring et al. (2005), the `demstock` package calculates stock as a cumulative weighted sum of all past values of a variable. Stock measures depreciate annually at a constant rate based on theoretical expectations or empirical observations about the long-run persistence of experiences.[2]

This working paper introduces the `demstock` package and describes its usage. The ability to measure states' experiences across a range of democracy indices presents new opportunities for exploring the historical legacies of political regimes. Indicator-level stock measures can facilitate more nuanced research on specific institutions and practices – such as civil society participation (see Bernhard and Edgell 2022), media freedoms, and women's rights. By allowing users to set their own depreciation rates, the `demstock` package also encourages more theoretically informed research, robustness testing, and face-validity checks about their potential legacies over time.

Materials and Methods

Our primary inspiration comes from Gerring et al. (2005), who conceptualize democratic stock as experience with democratic rule that accumulates (and depreciates) over time

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1. The `demstock` package is available via the V-Dem Institute Github account here: https://github.com/vdeminstitute/demstock

2. Gerring et al. (2005), for example, use an annual depreciation rate of one percent for levels of democracy based largely on trial and error.

within polities. Through the `demstock` package, we generalize the concept of stock to encompass a broad range institutions and practices associated with various types of political regimes using the V-Dem dataset.

Until recently, relatively few data existed on specific attributes of regimes (Boese 2019), making it difficult to assess historical legacies in a large-N framework. The V-Dem project helps overcome this data limitation problem by providing fine-grained data on various institutions and practices, in addition to several mid- and high-level indices, for over 200 polities as far back as 1789 (Coppedge et al. 2025a). The five high-level indices measuring electoral, liberal, participatory, deliberative, and egalitarian democracy lend opportunities to explore whether theories based on procedural or electoral definitions of democracy carry to alternative institutional arrangements (e.g., Edgell et al. 2018). V-Dem also includes 21 mid-level indices (e.g., freedom of association, civil society participation, and legislative constraints on the executive) and over 600 indicators (e.g., suffrage, election vote-buying, party bans, court packing, and freedom of religion), making it possible to assess the legacies of more specific institutions and practices.[3]

Our goal with the `demstock` package is to improve access to reliable stock measures for a long time-series across many cases. The process for generating stock measures may not be completely accessible to users who want to represent different institutional legacies in empirical models. The `demstock` package assists with this by providing an off-the-shelf solution with several options to customize stock measures for robustness and validity checks. To this end, we leverage the full extent of the V-Dem dataset, with the caveat that users should seriously consider whether the stock of a particular institution or practice makes conceptual sense, has meaningful implications, and depreciates at a constant (or variable) rate.

Using the Historical V-Dem data, the package calculates stock measures as far back as 1789 for 45 countries (Knutsen et al. 2019). This extends the democratic experience back to the advent of modern democracy represented by the American Constitution and the French Revolution, an improvement over measures starting in 1800 or 1900. Because V-Dem codes colonies and protectorates for much of the 20th century, the package can account for the accumulation of stock prior to independence.

Because variables in the data take different distributions, we begin by feature rescaling the desired variable using the common min/max method:

$$X'_{i,t} = \frac{X_{i,t} - X_{min}}{X_{max} - X_{min}} \tag{1}$$

Afterward, by default, we interpolate missing years between 1789 and 2021 (or the current end date of the V-Dem dataset) through two methods. First, for cases entering

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3. V-Dem collects these data primarily through its annual expert survey, with responses aggregated using a series of sophisticated reliability protocols and a state-of-the-art Bayesian measurement model (Pemstein et al. 2025).

the data after 1789 or that experience gaps in the V-Dem data, we use the V-Dem Country Coding Units documentation (Coppedge et al. 2025b) to interpolate values based on the antecedent or occupying regime where appropriate.[4] Table 1 of the appendix reports our re-coding decisions, which we also document in the package code. For other cases of missing data, we interpolate by filling forward the missing data by five years. Researchers who prefer to interpolate for a different interval of time or none at all may change this using the `fill` option in the package, as discussed below.

To calculate the raw stock measure, we take the weighted sum of all past values on the index/indicator. The weight by default is 0.99 (or 1% depreciation). Users may specify one or more different depreciation rates using the `val` option, as discussed below. We caution that specifying many depreciation rates will increase the computation time. We assume that countries enter the data with no stock and set the starting value for the first observed year to zero. All subsequent values are the previous year's stock multiplied by the weight (i.e., `val` or one minus the depreciation) plus the previous year's level of the re-scaled indicator.

The formula for calculating the *raw stock measure* $(d_{i,t}^{raw})$ is shown in Equation 2, where δ is one minus the depreciation rate. We assume that cases enter the sample with no accumulated stock $(d_0 = 0)$. For each subsequent year, we calculate stock as the previous year's depreciated stock plus the prior year's level of the indicator or index of interest (X).

$$d_{i,t}^{raw} = \sum_{s=0}^{t-1} \delta^{t-1-s} X_{i,s} \tag{2}$$

Equation 2 can also be rewritten as Equation 3 below.

$$d_{i,t}^{raw} = \delta d_{i,t-1} + X_{i,t-1} \tag{3}$$

Our formula is similar to Gerring et al. (2005), except that we include a one-year lag to ensure that the measure only captures *past* experiences and excludes information on current levels.[5]

While the raw stock measure is useful for certain applications, it is sensitive to the scale of the input variable (X) and to the number of years the unit has been observed within the sample. It is therefore difficult to interpret or compare across countries and indicators. For transparency and completeness, the `demstock` package provides this raw measure, but the more useful output is a rescaled version, which we describe below.

To improve interpretability and cross-country comparability, we rescale the raw stock to fall within the 0–1 interval. The *rescaled stock measure*, shown in Equation 4, is

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4. This follows Gerring et al. (2005) and Bernhard and Edgell (2022).

5. See also Leipziger (2016) and Gerring, Gjerløw, and Knutsen (2020).

calculated by multiplying the raw stock by $(1 - \delta)$:

$$d_{i,t} = (1 - \delta) \sum_{s=0}^{t-1} \delta^{t-1-s} X_{i,s} \tag{4}$$

This form of rescaling follows existing practice in the literature. Persson and Tabellini (2009, Equation 12, p. 101) apply a similar transformation to normalize a discounted stock to the [0,1] interval. Conceptually, this transformation reflects the fact that the highest possible value the raw stock could ever attain (i.e. assuming it was a perfect score in every year) is:

$$\lim_{t \to \infty} \sum_{s=0}^{t-1} \delta^{t-1-s} = \frac{1}{1-\delta}$$

Multiplying the raw stock by $(1 - \delta)$ transforms it into a measure that shows how close a country has come to the maximum possible accumulated stock — that of a country that has always scored perfect on the selected index or indicator. The adjusted stock measure ranges from 0 to 1 and can be interpreted as the share of the maximum stock theoretically possible under a given depreciation rate.

In sum, the `demstock` package provides two versions of stock:

- **Adjusted (Rescaled) Stock:** The recommended output for most applications. It shows how much stock a country has accumulated relative to a hypothetical country that has always scored perfect for the selected indicator or index.

- **Raw Stock:** Provided for transparency and robustness checks; not recommended for direct interpretation or cross-country comparisons.

Data Package Description

With the `demstock` package, our goal is to assist in more general longitudinal and cross-national analyses of theories concerning the historical legacies of regimes (both their institutions and practices), as well as, case selection for small- and medium-N studies. The package is accessible through the V-Dem Institute Github and can be directly downloaded into the R statistical software through the command line by first installing the `devtools` package.

The primary command in the `demstock` package is `get_stock()`. Noting that many will simply require a conventional measure of aggregate democratic stock, the `get_stock()` command by default calculates the stock of electoral democracy (*v2x_polyarchy*) from the current version of the V-Dem dataset using a one-percent depreciation rate. This produces a dataframe object containing the V-Dem country name, country identifier, year, and the adjusted (rescaled) stock of electoral democracy with a one-percent depreciation

rate, and the raw version for transparency (see above). The `demstock` package includes several options to allow users to calculate stock measures from other indicators and indices using different depreciation rates and versions of the V-Dem dataset.

Selecting variables to measure as a stock

Using the option `var`, users can select one or more variables from the V-Dem dataset to measure as a stock. For multiple variables, `var` must receive a vector of values. For example, c(``v2x_polyarchy'', ``v2x_libdem'') will calculate stock measures for the electoral and liberal democracy indices.

We caution against arbitrarily selecting and calculating stock variables without a good theoretical and empirical justification. Scholars should consider whether stock of a particular institution or practice makes sense conceptually and is empirically relevant to the research question. Furthermore, the feasibility of calculating a valid stock measure will depend on the level of measurement of the original variable and informed decisions about the depreciation rate (see below).

As an example, rapid changes in the CSO participatory environment may not accurately capture CSO capacity resulting from accumulated experience (Bernhard and Edgell 2022). Figure 1 illustrates this using the indicator for CSO participatory environment (*v2csprtcpt*) and its stock with a ten-percent depreciation rate for three countries in North Africa.[6] With a ten-percent depreciation rate, stock is less susceptible to sudden increases or decreases in values for a given year (Bernhard and Edgell 2022); instead, it slowly accumulates and depreciates over time. Tunisia's CSO participatory environment rapidly improved after the Arab Spring but its stock increased at a slower pace, reflecting the newness of these freedoms. Similarly, we see a large jump in the CSO participatory environment in Sudan during the 2018 uprising; however, its stock remains substantially lower as a consequence of years of repression under Oumar al-Bashir's regime. Libya is an example of how the default settings deal with gaps in the data – in this case, values are not filled forward more than 5 years, resulting in no observations for the stock measure after a gap from 1941 to 1951.

Setting the depreciation rate(s)

The option `val` sets the depreciation rate(s) to any value(s) between zero and one. Users should specify one minus the depreciation rate – e.g., 0.99 for a one percent depreciation. For multiple depreciation rates, `val` must receive a vector of values. For example, c(0.99, 0.90) will calculate one percent and ten percent depreciation rates. By calculating stock

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6. For comparability, we have feature rescaled both measures using the min/max procedure. The command to produce this stock measure is get_stock(var="v2csprtcpt", val=.90).
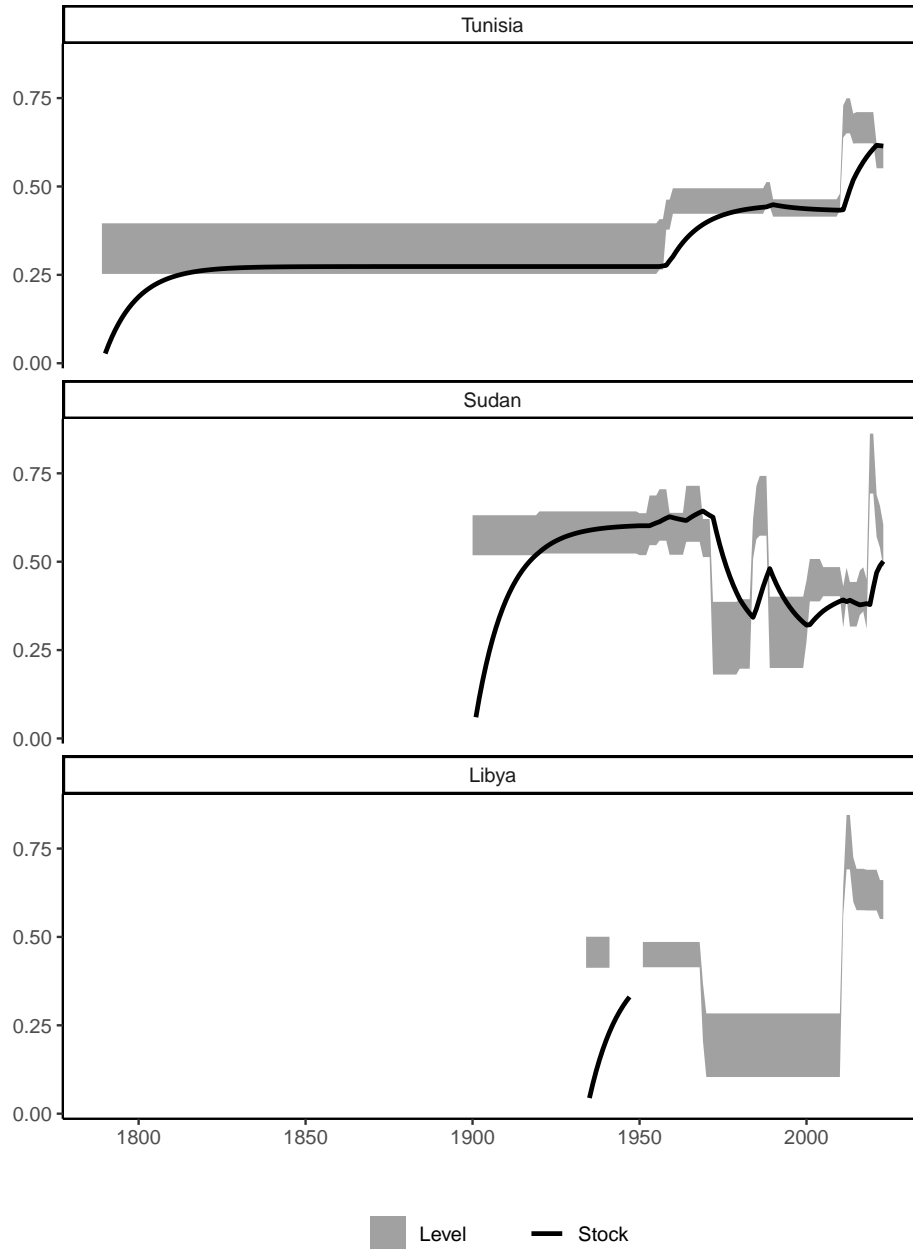
Figure 1. Levels and stock (10% depreciated) of the
CSO participatory environment in North Africa.
(Interval based on high and low estimates for *v2csprtcpt*.)

measures with various depreciation rates, scholars can assess the extent to which regime attributes in the past continue to affect present-day outcomes over the long-run.

Scholars will need to think carefully about the most appropriate depreciation rate and whether stock depreciates at a constant or variable rate for their indicator(s) of interest. For example, Bernhard and Edgell (2022) suggest using a repression-based depreciation rate when calculating civil society stock. The `demstock` package is currently limited to a constant depreciation rate for all country-years. Future updates may allow users to select variable (theoretically-informed) weights.
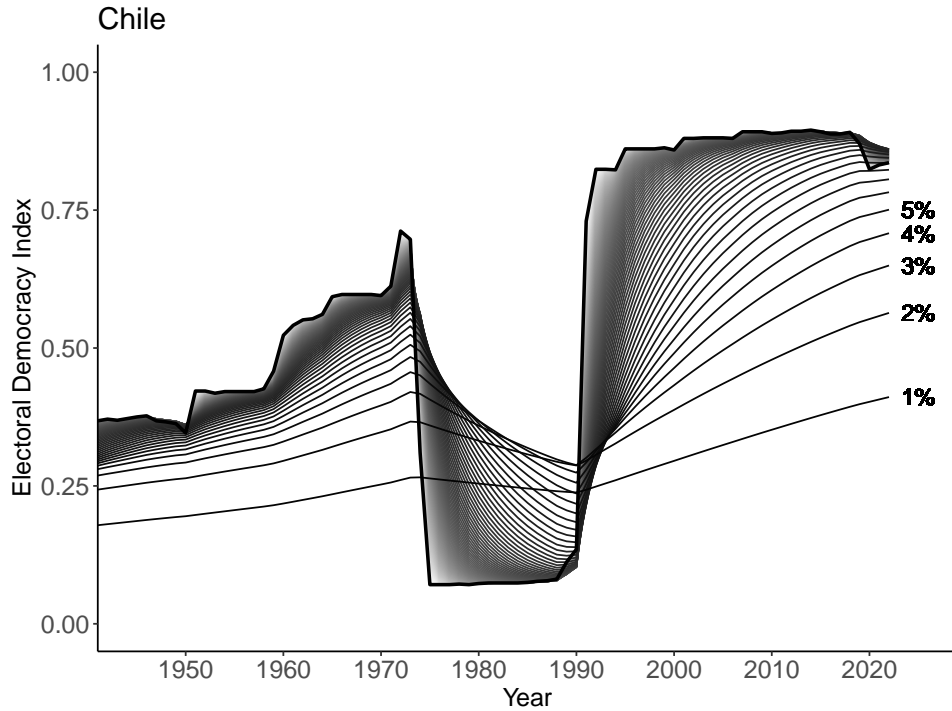
Figure 2. Electoral democracy stock in Chile with varying depreciation rates.

To illustrate, Figure 2 shows the level of electoral democracy for Chile after World War II (*v2x_polyarchy*), overlaid with stock measures based on different depreciation rates. Stock values with lower depreciation rates are much less sensitive to year-to-year changes. A one-percent depreciation rate, for example – which Gerring et al. (2005) used –, is not as strongly affected by the impact of military rule under Pinochet starting in 1973 and the restoration of democracy in 1991. The choice of depreciation rate determines the sensitivity to short-run changes, with lower rates reflecting more gradual accumulation over time. As the depreciation rate moves to 99%, all stock measures converge on a second-order lag of contemporaneous values.

Dealing with gaps

The calculation of stock depends on continuous values over time and returns a value of missing for all country-years after there is a missing value for the original variable. An important decision, therefore, concerns how users handle missing values. As a general rule, we recommend that (a) observations are not carried forward for more than 5 years and (b) only if five years of data exist prior to the missing spell. By default, the `get_stock()` command does this calculation for users. Options in the package allow users to deviate from the five year rule using `fill=N`, where N is the number of years to fill missing data. Thus, if the user does not want to fill any missing values, they can specify `fill=0`. The stock variable will include missing values for all country-years after a gap in coding longer than the specified N period using the `fill` option.

Including other V-Dem variables

The package allows users to attach additional variables from the V-Dem dataset using the option `add=`. This avoids having to merge additional V-Dem data after calculating stock values. For multiple variables, the package must receive a vector of values – e.g., `add=c(''v2x_regime'', ''v2elmulpar'')` would include the Regimes of the World index and multiparty elections indicators in their level forms.

Discussion

Scholars frequently turn to historical legacies to explain political and socioeconomic outcomes of interest, such as economic performance, societal norms, and regime change. Cross-national measures of accumulated experience, or *stock*, are therefore crucial for empirically representing legacy effects typically described in the case-based literature.

However, the lack of access to off-the-shelf measures of stock across the full range of institutions and practices associated with political regimes hampers the ability for scholars to explore important empirical questions concerning the role of democratic experience. Large-N applications remain limited in volume (number of articles) and scope (areas of inquiry). While this could reflect a narrow focus on replication, borrowing, and repurposing of existing data, it also highlights the challenges of operationalizing long-run effects for different variables.

Drawing on Gerring et al. (2005), the `demstock` R package allows researchers to obtain stock measures of virtually any variable in the V-Dem dataset. By making stock measures accessible, the package aims to enhance the quality, quantity, and range of scholarship that takes seriously the long-run legacy effects of institutions and practices. We encourage scholars to use the package when the research puzzle at hand centers on legacies and when they can draw on case-based work to make logical and informed decisions about depreciation rates.

At present, we lack a solid understanding of how political experiences accumulate and decay, despite suspecting that it often matters. For these situations, the `demstock` package facilitates the creation of measures that represent longer term time dependence and allows scholars to more seriously consider whether and to what extent historical regime attributes affect political outcomes.

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Appendix

Table 1. Historical attribution for countries in the sample

Country name (id)	Dates	Recoded as country name (id)
Albania (12)	1789-1911	Turkey (99)
Yemen (14)	1851-1917	Turkey (99)
Poland (17)	1796-1808	Russia (11)
Poland (17)	1868-1917	Russia (11)
Poland (17)	1939-1943	Germany (77)
South Yemen (23)	1838-1899	India (39)
Bangladesh (24)	1858-1946	India (39)
Bangladesh (24)	1947-1970	Pakistan (29)
Bolivia (25)	1810-1824	Argentina (37)
Pakistan (29)	1858-1946	India (39)
South Sudan (32)	1900-2010	Sudan (33)
Vietnam (34)	1802-1944	Republic of Vietnam (35)
North Korea (41)	1789-1944	South Korea (42)
Kosovo (43)	1789-1912	Turkey (99)
Kosovo (43)	1913-1998	Serbia (198)
Lebanon (44)	1789-1830	Turkey (99)
Lebanon (44)	1831-1841	Egypt (13)
Lebanon (44)	1842-1918	Turkey (99)
Venezuela (51)	1820-1829	Colombia (15)
Burkina Faso (54)	1932-1946	Average Ivory Coast (64), Mali (28), and Niger (60)
Central African Republic (71)	1903-1919	Republic of Congo (112)
Ecuador (75)	1810-1829	Colombia (15)
Germany (77)	1945-1948	Austria (144)
Iraq (80)	1831-1919	Turkey (99)
Ireland (81)	1789-1918	United Kingdom (101)
Italy (82)	1789-1861	Piedmont-Sardinia (373)
Jordan (83)	1789-1802	Turkey (99)
Jordan (83)	1803-1818	Saudi Arabia (197)
Jordan (83)	1819-1832	Turkey (99)
Jordan (83)	1833-1841	Egypt (13)
Jordan (83)	1842-1918	Turkey (99)
Jordan (83)	1919-1921	Syria (97)
Latvia (84)	1789-1919	Russia (11)
Latvia (84)	1940-1989	Russia (11)
Mongolia (89)	1789-1910	China (110)

Table 1. (continued)

Country name (id)	Dates	Recoded as country name (id)
Netherlands (91)	1811-1812	France (76)
Panama (92)	1710-1902	Colombia (15)
Qatar (94)	1871-1899	Turkey (99)
Syria (97)	1789-1830	Turkey (99)
Syria (97)	1831-1841	Egypt (13)
Syria (97)	1842-1917	Turkey (99)
Ukraine (100)	1789-1989	Russia (11)
Uruguay (102)	1810-1820	Argentina (37)
Uruguay (102)	1821-1824	Brazil (19)
Armenia (105)	1826-1989	Russia (11)
Azerbaijan (106)	1814-1989	Russia (11)
Belarus (107)	1789-1989	Russia (11)
Chad (109)	1903-1919	Republic of Congo (112)
Dominican Republic (114)	1823-1843	Haiti (26)
Georgia (118)	1800-1989	Russia (11)
Kazakhstan (121)	1789-1990	Russia (11)
Kyrgyzstan (122)	1876-1989	Russia (11)
Moldova (126)	1789-1811	Turkey (99)
Moldova (126)	1812-1917	Russia (11)
Moldova (126)	1918-1939	Romania (190)
Moldova (126)	1940-1941	Russia (11)
Moldova (126)	1942-1944	Romania (190)
Moldova (126)	1945-1989	Russia (11)
Tajikistan (133)	1864-1989	Russia (11)
Turkmenistan (136)	1864-1990	Russia (11)
German Democratic Republic (137)	1789-1944	Germany (77)
Somaliland (139)	1960-1990	Somalia (130)
Uzbekistan (140)	1921-1989	Russia (11)
Austria (144)	1939-1944	Germany (77)
Bosnia and Herzegovina (150)	1918-1991	Serbia (198)
Bulgaria (152)	1789-1877	Turkey (99)
Comoros (153)	1914-1945	Madagascar (125)
Croatia (154)	1867-1918	Hungary (210)
Croatia (154)	1919-1940	Serbia (198)
Croatia (154)	1945-1990	Serbia (198)
Czech Republic (157)	1789-1917	Austria (144)
Estonia (161)	1789-1917	Russia (11)
Estonia (161)	1940-1989	Russia (11)
Greece (164)	1789-1821	Turkey (99)

Table 1. (continued)

Country name (id)	Dates	Recoded as country name (id)
Iceland (168)	1843-1899	Denmark (158)
Lithuania (173)	1789-1794	Poland (17)
Lithuania (173)	1795-1917	Russia (11)
Lithuania (173)	1940-1989	Russia (11)
Macedonia (176)	1789-1911	Turkey (99)
Macedonia (176)	1912-1990	Serbia (198)
Montenegro (183)	1789-1899	missing values
Saudi Arabia (197)	1819-1821	Egypt (13)
Slovakia (201)	1945-1992	Czech Republic (157)
Slovenia (202)	1789-1918	Austria (144)
Slovenia (202)	1919-1988	Serbia (198)
Parma (352)	1803-1814	France (76)
Papal States (361)	1810-1813	France (76)