In this paper we follow the geographical categorization adopted by the Clio-Infra project (www.clio-infra.eu). While the Polity IV reports data on current political units, the Vanhanen dataset reflect historical changes in naming and also report data for non-existing countries. The transformation into the Clio-Infra template result in a minor loss of observations for the early periods. Also, when the PolityIV assigns weight to special events like foreign interruption, interregnum and transition (codes -66, -77, -88 respectively), we treated these as missing values. The number of available observation for a few benchmark years is summarized in Table 2.

Table 2
Number of countries in different benchmark years

year	polity2	ID	log of GDP p.c.	av. years of educ.
1860	40	44	28	8
1870	50	44	66	23
1890	51	47	44	49
1910	56	51	44	63
1930	68	64	54	96
1950	78	79	139	117
1970	127	135	146	149
1990	141	157	162	145
2000	158	171	161	144

3. Methodology

The underlying assumption of this paper is that all seven observed components are all empirical realizations of the same underlying democracy variable (D). This allows us to express the vector of components (**y**) as a function of a single underlying factor for each year.

$y_{ij} = \alpha_{0j} + \alpha_{1j} D_i + \varepsilon_{ij}$ (1) where i denotes the country (i=1…n) and j denotes the indicator (j=1…7). The parameters α_{0j} and α_{1j} are the indicator specific constants and loadings, D_i is the latent democracy score for country i assumed to have zero mean, and ε_{ij} denotes the random country and indicator specific part of y_{ij} with zero mean, such as the effect of measurement errors, or even the effect of incorrect scaling.

Equation (1) can be rewritten in terms of variances:

$\mathbf{\Sigma_Y} = \boldsymbol{\alpha}^{\mathbf{T}} \boldsymbol{\alpha} \sigma_D^2 + \mathbf{\Sigma_\varepsilon}$ (2) where Σ_Y and Σ_ε denote the covariance matrices for the observed variables and the errors respectively, $\boldsymbol{\alpha}$ is the loading vector and σ_D^2 is the variance of the latent democracy measure. Since we assumed that the measurement errors are uncorrelated,

Σ_ε is a positive semidefinite diagonal matrix and all observed covariance between the indicator variable y must be caused by the underlying single factor D. These results in a system of equations that can be compactly written in matrix form:

$$\begin{bmatrix} \sigma_{y_1}^2 & \sigma_{y_1y_2} & \cdots & \sigma_{y_1y_k} \\ \sigma_{y_1y_2} & \sigma_{y_2}^2 & \cdots & \sigma_{y_2y_k} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{y_1y_k} & \sigma_{y_2y_k} & \cdots & \sigma_{y_k}^2 \end{bmatrix} = \begin{bmatrix} \alpha_{11}^2 & \alpha_{11}\alpha_{12} & \cdots & \alpha_{11}\alpha_{1k} \\ \alpha_{11}\alpha_{12} & \alpha_{12}^2 & \cdots & \alpha_{12}\alpha_{1k} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{11}\alpha_{1k} & \alpha_{12}\alpha_{1k} & \cdots & \alpha_{1k}^2 \end{bmatrix} \sigma_D^2 + \begin{bmatrix} \sigma_{\varepsilon_1}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{\varepsilon_2}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{\varepsilon_k}^2 \end{bmatrix} \quad (3)$$

Since the measurement scale of the indicators is different we rather use standardized indicators, which modifies (3) slightly:

$$\begin{bmatrix} 1 & \rho_{y_1y_2} & \cdots & \rho_{y_1y_k} \\ \rho_{y_1y_2} & 1 & \cdots & \rho_{y_2y_k} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{y_1y_k} & \rho_{y_2y_k} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} \tilde{\alpha}_{11}^2 & \tilde{\alpha}_{11}\tilde{\alpha}_{12} & \cdots & \tilde{\alpha}_{11}\tilde{\alpha}_{1k} \\ \tilde{\alpha}_{11}\tilde{\alpha}_{12} & \tilde{\alpha}_{12}^2 & \cdots & \tilde{\alpha}_{12}\tilde{\alpha}_{1k} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{\alpha}_{11}\tilde{\alpha}_{1k} & \tilde{\alpha}_{12}\tilde{\alpha}_{1k} & \cdots & \tilde{\alpha}_{1k}^2 \end{bmatrix} \sigma_D^2 + \begin{bmatrix} \sigma_{\eta_1}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{\eta_2}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{\eta_k}^2 \end{bmatrix} \quad (4)$$

That is we use the correlation matrix instead of the covariance matrix.

So that the system is identified the loading of the first indicator (xrcomp) is set to unity, that is $\alpha_{11} = \tilde{\alpha}_{11} = 1$. Since the system is overidentified the parameters were estimated by an ML method. While the above model is estimated for every year from 1850 to 2000, we only report the results for some benchmark years in the Appendix.

Another way to visualize the underlying model is a measurement model or factor model:

Figure 2

The measurement model behind the latent democracy indicator

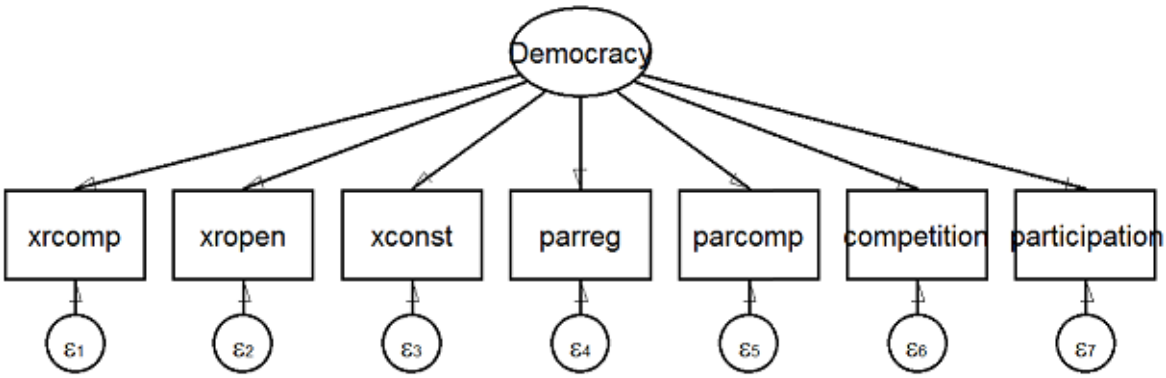


Table 3 reports the summary statistics of the estimated latent indicator D for a few benchmark years.

Table 3

Descriptive statistics of the estimated Democracy variable (D) in benchmark years

year	number of obs	mean	standard deviation
1850	38	0.018	0.654
1870	40	0	0.827
1890	46	-0.009	0.866
1910	49	0.015	0.897
1930	59	-0.019	0.802
1950	76	-0.011	0.871
1970	120	-0.054	0.828
1990	132	-0.004	0.848
2000	139	0.003	0.869

Note: estimated from standardized indicators

Table 4 reports the portion of variance of the indicators not explained by the common factor D (specific variance or one minus communality).

Table 4

Proportion of specific variance in a few benchmark years

	1850	1870	1890	1910	1930	1950	1970	1990	2000
XRCOMP	19%	23%	17%	15%	33%	20%	28%	25%	23%
XROPEN	24%	28%	22%	25%	32%	29%	32%	31%	32%
XCONST	69%	53%	74%	54%	14%	23%	19%	12%	11%
PARREG	78%	87%	57%	61%	39%	31%	6%	12%	23%
PARCOMP	88%	88%	66%	65%	34%	28%	7%	9%	18%
competition	88%	86%	89%	72%	12%	28%	16%	14%	18%
participation	72%	24%	79%	66%	27%	83%	82%	59%	49%

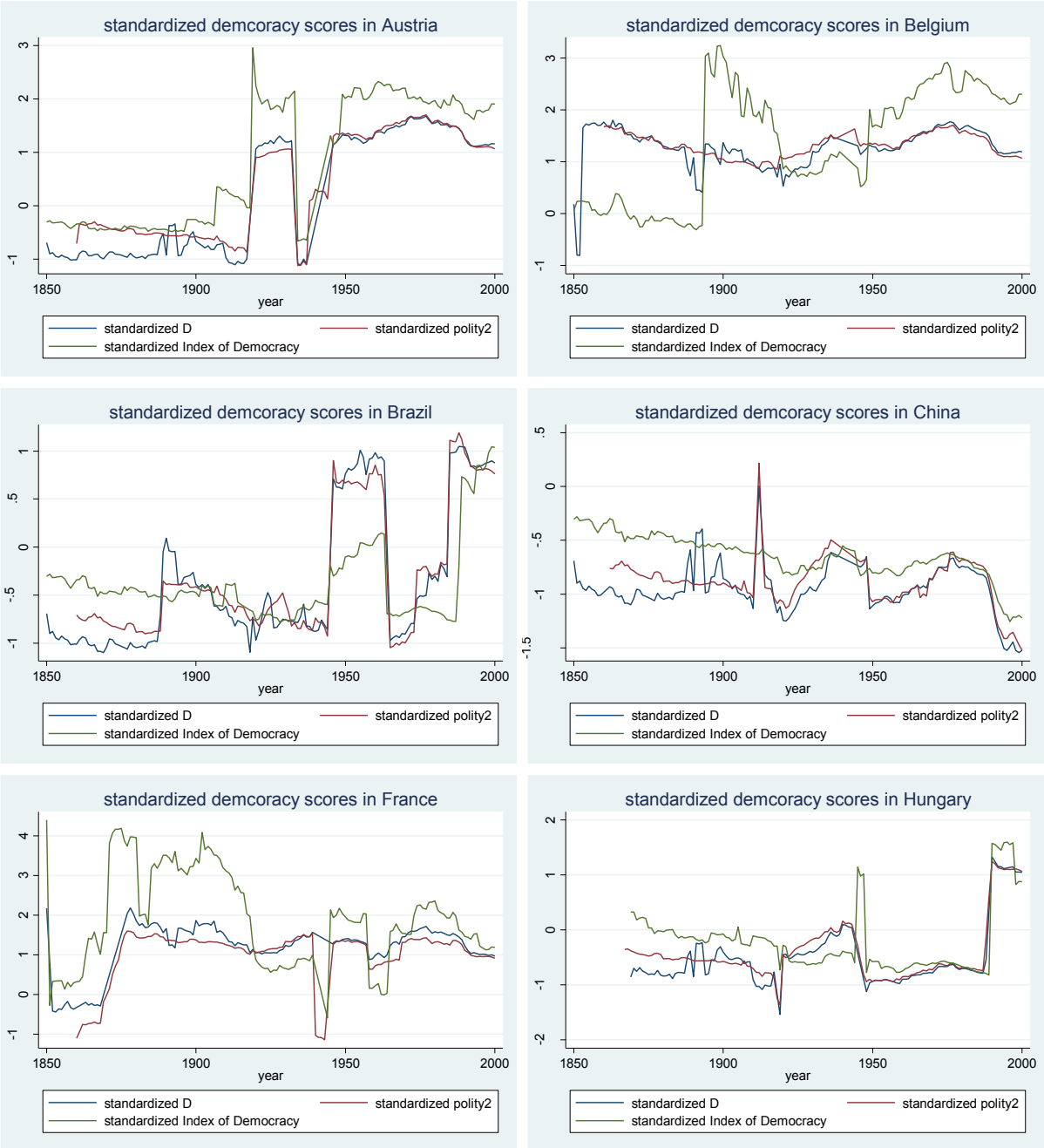
Table 4 reveals that the different democracy components were reflecting the latent democracy to different extents. The quality of the indicators improved over time, while the average share of individual specific effects, including measurement errors decreased from 62% in 1850 to 25% in 2000 on average. The communality of the competitiveness of executive recruitment process remains relatively stable indicating that if one were to select only a single component to obtain a picture of democracy it should be the XRCOMP. Nevertheless, the changing communality of the components over time reveals a structural change in the factors behind democracy. It is noteworthy that it are the PARCOMP and PARREG components of the polity2 together with the competition component of the ID that show the greatest degree of improvement, indicating that once the last wave of democratization began in the 1970s, competition became the primary factor behind democracy, while the relative importance of participation decreased.

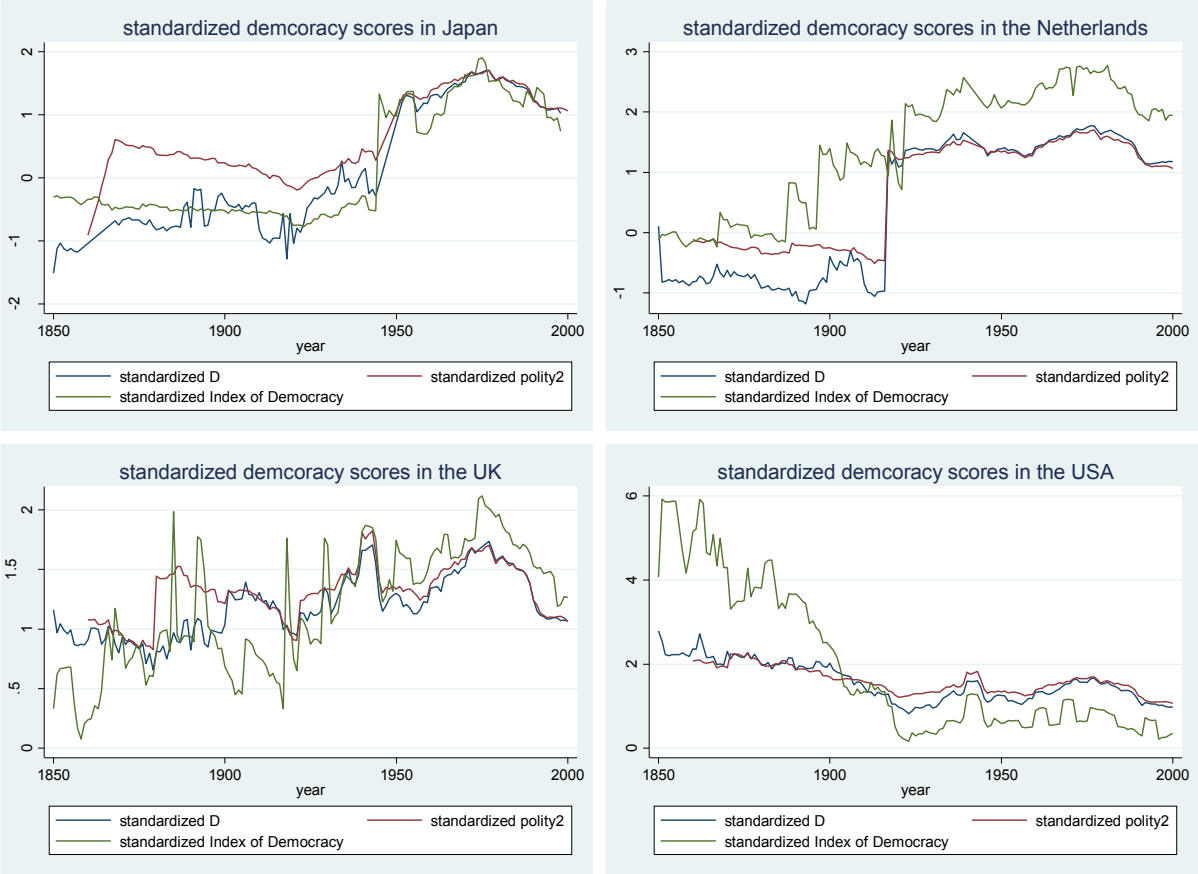
4. Trends in democracy

Using the latent democracy variable D, we can visualize some patterns. Figure 3 visualizes the relationship between the polity2, the ID and the latent D in a few countries over time. Due to differences in measurement units, we report standardized indicators.

Figure 3

Comparison the latent democracy indicator and polity2 and ID scores in eight countries 1850-2000



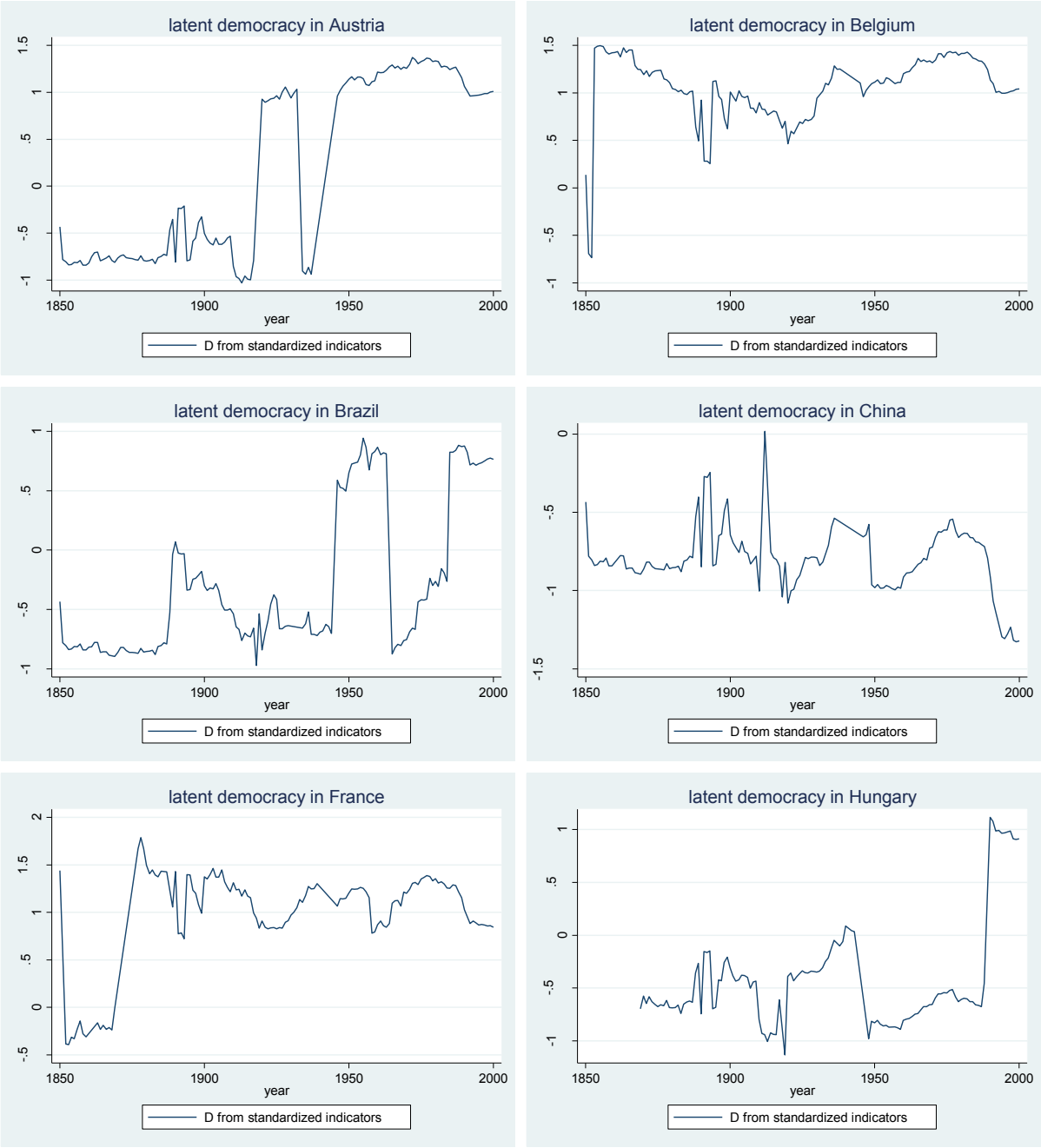


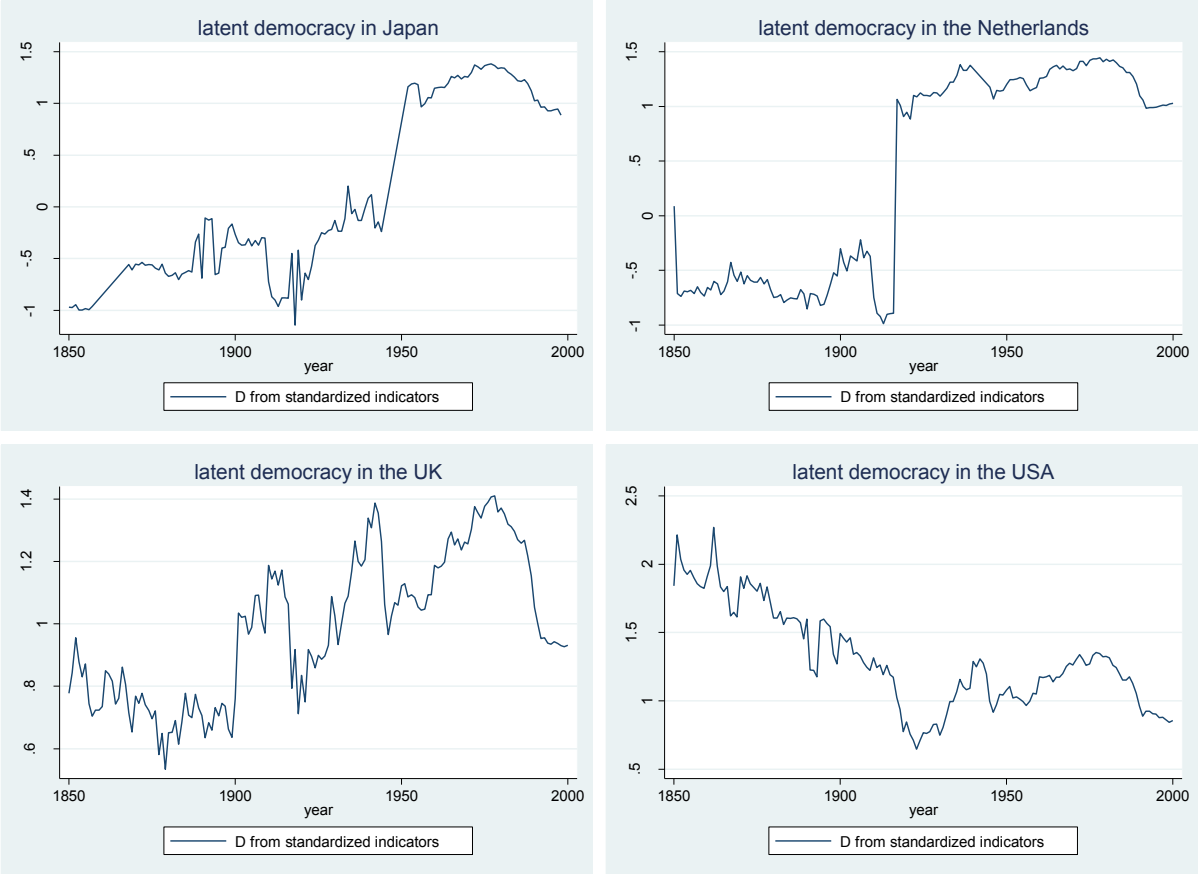
Note: the indicators are standardized by year, that is a value 1 on this graph means that an indicator in a particular country was one standard deviation above the mean in that year.

The latent democracy measure reflects broadly the same trend as polity2 and the Index of Democracy. It should be born in mind, though, that standardization itself fundamentally changes the interpretation of the graphs above, since by subtracting the annual mean scores and normalizing the standard deviation, the democracy is now depicted as a relative phenomenon, and not a concept measurable on an absolute scale. A high score refers to a score that is exceptional relative to the rest of the countries in the sample, and the effect of this can be seen the most explicitly on the USA, where he relative degree of democracy is falling in terms of all measures. The unstandardized latent democracy scores reveal a similar picture in Figure 4, the reason being that these are also based on cross-sectional estimates per years, hence the trends over time reflect a change in the relative rather than in the absolute position of a country. The score should be compared only within the same year. For example, the D score of the USA in 2000 was 0.856, which is lower than that of the UK in the same year (0.932), which coincides with the picture derived from the Index of Democracy, but it is still higher than that of 79% of the 181 countries in the sample.

Figure 4

The latent democracy variable in ten countries (absolute scores)



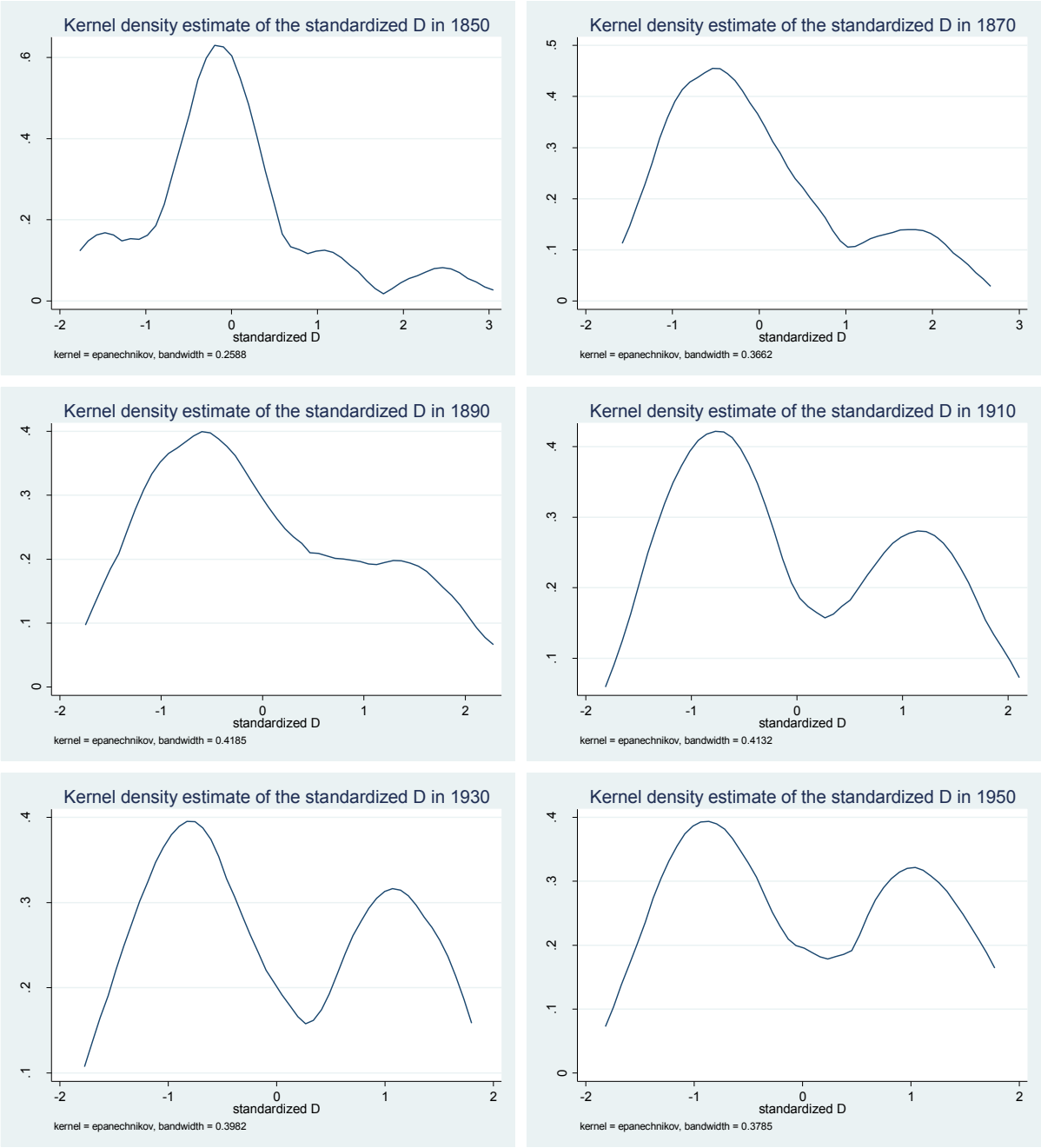


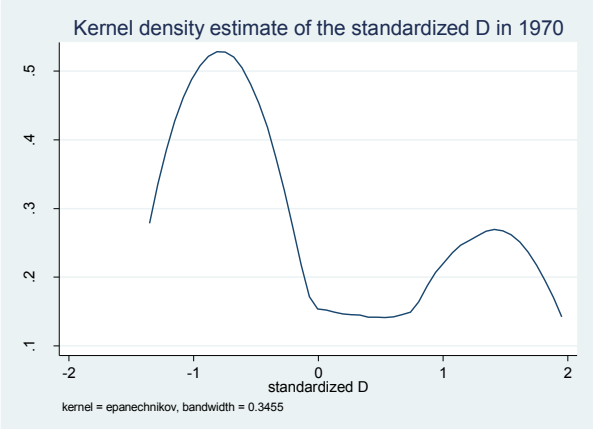
We find that while the USA had some initial advantage in terms of democracy over the rest of the World, it slowly eroded over time and converged to the level of other Western democracies. We can observe the effects of exogenous regime changes as well. Japan experienced a jump in democratization after World War 2, just like Hungary after 1989, lending credibility to the above figures.

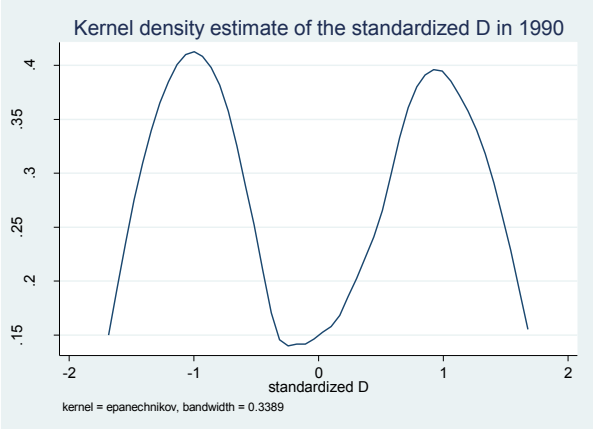
The distribution of the latent democracy variable is estimated with kernel density estimators for a few benchmark years (Figure 5). We find that the initial unimodal distribution, which reflects a degree of relative homogeneity of democracy, was soon replaced by a bimodal distribution, taking shape in the beginning of the 20th century, and remaining in place for the rest of the 1900s. We find the strongest bifurcation of regimes in 1990, when most regimes seem to have been gravitated to one of the two centres. It is only in the last year, 2000, that we find a movement toward a unimodal distribution again, signifying the effect of a global democratization process.

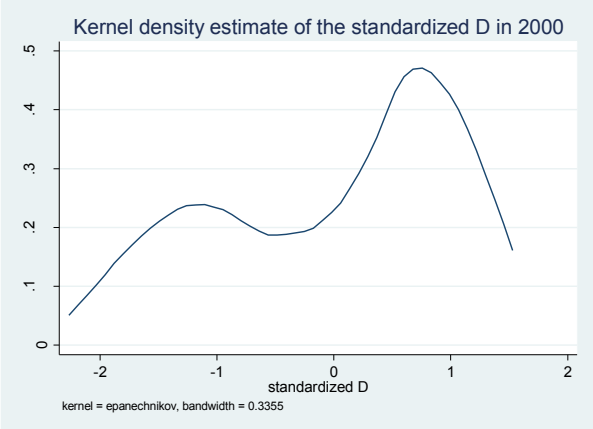
Figure 5

Kernel density estimates of the latent democracy index (D) for benchmark years









5. Conclusion

In this paper we applied a factor analysis based on a measurement error model to extract a latent democracy measure from five components of the Polity IV project and two components of Vanhanen's Index of Democracy. Since both set of indicators reflect the basic components of democracy as introduced by Dahl (1972) there is a reason to assume that the cross-sectional variance of the observable components reflect the effect of a single underlying latent factor.

An obvious advantage of using the estimated factor in further statistical analysis is that the model takes the measurement and observation errors directly into account. Yet, this comes at a price, since the resulting component reflect cross-country differences and should accordingly be treated as a relative and not absolute measure of democracy.

The distribution of the estimated latent democracy reflect an initial divergence in the second half of the 19th century, only replaced by a divergence in the last decade of the 20th century.

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Appendix

Table A.1

Results from the measurement error model for benchmark years

	1850	1870	1890	1910	1930	1950	1970	1990	2000
xrcomp	1	1	1	1	1	1	1	1	1
t-stat	fixed	fixed	fixed	fixed	fixed	fixed	fixed	fixed	fixed
constant	0.072	0.042	0.055	0.053	0.084	0.037	0.005	0.018	-0.009
t-stat	-0.44	-0.27	-0.38	-0.37	-0.65	-0.32	-0.06	-0.21	-0.11
xropen	0.948***	0.950***	0.961***	0.876***	0.861***	0.927***	0.985***	0.973***	0.946***
t-stat	-7.14	-6.45	-8.87	-8.94	-7.02	-10.39	-11.5	-12.78	-13.35
constant	0.068	0.056	0.038	0.082	0.147	0.039	-0.01	0.009	-0.014
t-stat	-0.42	-0.36	-0.26	-0.6	-1.25	-0.34	-0.11	-0.1	-0.16
xconst	0.527***	0.737***	0.481***	0.685***	1.127***	0.982***	1.071***	1.097***	1.066***
t-stat	-3.21	-4.33	-2.93	-4.49	-8.68	-10.9	-13.38	-16.34	-17.76
constant	0.016	0.027	0.09	0.111	0.086	0.033	-0.017	-0.002	0
t-stat	-0.1	-0.18	-0.62	-0.79	-0.66	-0.28	-0.18	-0.02	-0.00
parreg	0.519***	0.340*	0.749***	0.648***	0.933***	0.913***	1.158***	1.094***	0.994***
t-stat	-2.87	-1.83	-4.38	-4.04	-6.82	-9.26	-15.66	-16.21	-14.88
constant	-0.05	-0.065	-0.049	0.001	0.053	0.017	0.016	-0.005	-0.011
t-stat	-0.31	-0.42	-0.33	-0.01	-0.42	-0.15	-0.18	-0.06	-0.12
parcomp	0.466**	0.364*	0.721***	0.583***	0.964***	0.941***	1.158***	1.109***	1.010***
t-stat	-2.43	-1.91	-4.01	-3.55	-7.16	-9.68	-15.35	-16.83	-15.79
constant	-0.031	-0.061	-0.024	0.021	0.081	0.037	0.012	-0.006	-0.011
t-stat	-0.18	-0.39	-0.15	-0.15	-0.63	-0.32	-0.13	-0.06	-0.13
competition	0.387**	0.446**	0.342*	0.499***	1.140***	0.952***	1.091***	1.073***	1.020***
t-stat	-2.14	-2.2	-1.94	-3.1	-8.82	-10.23	-13.85	-15.94	-16.06
constant	0.035	-0.024	0.042	-0.036	0.075	-0.019	0.01	-0.013	0.009
t-stat	-0.22	-0.15	-0.28	-0.26	-0.58	-0.16	-0.11	-0.15	-0.11
participation	0.601***	0.395***	0.512***	0.666***	1.074***	0.439***	0.502***	0.738***	0.789***
t-stat	-3.46	-3.64	-2.98	-4.09	-7.71	-3.51	-4.77	-8.37	-10.04
constant	0.019	-0.178*	0.029	0.03	0.067	-0.026	0.031	0.038	0
t-stat	-0.11	-1.89	-0.19	-0.2	-0.5	-0.23)	-0.34	-0.43	-0.01

var(e.xrcomp)	0.187**	0.229**	0.165*	0.146	0.329***	0.198***	0.284***	0.248***	0.228***
t-stat	-2.05	-2.33	-1.92	-1.53	-4.6	-4.19	-7.22	-7.36	-7.18
var(e.xropen)	0.235***	0.277***	0.218***	0.248***	0.315***	0.285***	0.324***	0.314***	0.323***
t-stat	-2.69	-2.88	-2.64	-2.82	-4.84	-4.77	-7.28	-7.5	-7.57
var(e.xconst)	0.689***	0.530***	0.742***	0.540***	0.144***	0.232***	0.188***	0.120***	0.105***
t-stat	-4.16	-3.86	-4.54	-4.09	-3.8	-4.88	-6.78	-6.31	-5.63
var(e.parreg)	0.784***	0.873***	0.569***	0.608***	0.391***	0.312***	0.058***	0.124***	0.232***
t-stat	-4.16	-4.4	-3.77	-4.18	-4.79	-4.88	-4.62	-6.32	-7.18
var(e.parcomp)	0.875***	0.878***	0.656***	0.650***	0.342***	0.279***	0.072***	0.093***	0.183***
t-stat	-4.19	-4.39	-3.93	-4.28	-4.81	-4.63	-5.29	-5.66	-6.83
var(e.competition)	0.876***	0.856***	0.886***	0.715***	0.117***	0.281***	0.162***	0.136***	0.176***
t-stat	-4.27	-4.27	-4.64	-4.56	-3.28	-5.17	-6.58	-6.62	-6.82
var(e.participation)	0.716***	0.237***	0.788***	0.657***	0.274***	0.827***	0.819***	0.593***	0.491***
t-stat	-4.1	-4.05	-4.51	-4.28	-4.62	-6.05	-7.67	-7.94	-7.98
var(D)	0.838***	0.757***	0.817***	0.863***	0.650***	0.793***	0.697***	0.736***	0.782***
t-stat	-3.42	-3.29	-3.73	-3.87	-3.71	-4.89	-5.69	-6.21	-6.54
N	34	40	45	48	58	75	119	131	138