August 11 - 2023

Net-Appendix to

Income, Growth, and Democracy

Looking for the causal structure

Content:

$X(y)$ is the key relation in the A-theory has (A), while $g(X)$ is the key relation in the B-theory. The relations are estimated by kernel regressions: $K^X(y, \text{bw})$ and $K^g(X, bw)$. The data are for the ***Main*** sample, the ***gT*** sample where *g* is truncated, and the ***yT*** sample where also *y* is truncated, see the main paper. Figures and tables are numbered with A# in the Appendix, and with # only in main paper. Sections, figures, and tables have the same A-number in this appendix.

Table. Variables and relations analyzed. Same as in main paper

Type	Name	Variable
National accounts data	*gdp*	Real GDP per capita in PPP-prices
	g	Growth rate for the *gdp*
	g^T	Growth rate truncated to [-10, 12]
	y	Income, ln *gdp*
	y^T	Income truncated to $y < 10$
Democracy indices X	F	Freedom house index rescaled to C-scale
	P	Polity2 index rescaled to C-scale
	V	Polyarchy index rescaled to C-scale
First differences dX	dF	First difference to F
	dP	First difference to P
	dV	First difference to V

Relations	
(A)	$X(y)$
(Ar)	$y(X)$
(B)	$g(X)$
(Br)	$X(g)$
(L)	$g(y)$
(Lr)	$y(g)$

The C-scale is reported in Table 2 of main paper. It is in % of the range of each index. The calculations use the Main sample but before Bahrain and Oman was excluded.

A1 (A) The X = X(y) transition curves

Figure A1 shows the three transition curves. On figure A1 the 95% confidence intervals for the *bw* = 0.4, and two curves with the bandwidth 0.25 and 0.65. *Bw* = 0.25 is chosen as too small, so the curve is a bit wobbly. *Bw* =0.65 is chosen as too large, so the curve is too straight. Still all nine curves show the same picture.

Figure A1.1

$F(y) \approx K^F(y, bw)$

For three *bw*'s

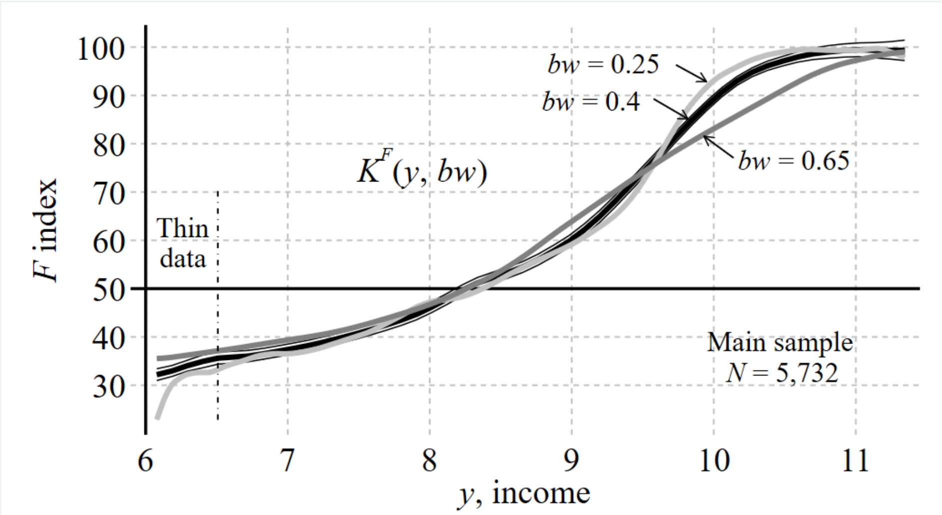


Figure A1.2

$P(y) \approx K^P(y, bw)$

For three *bw*'s

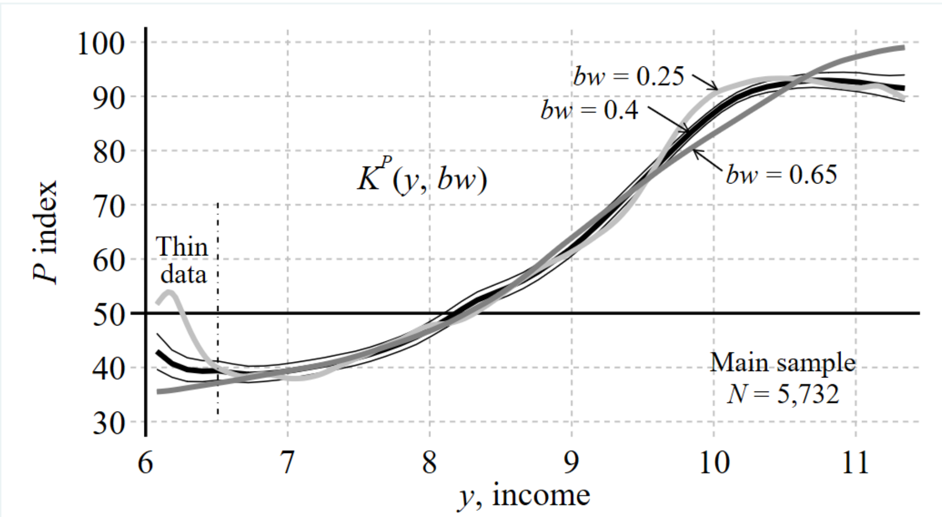
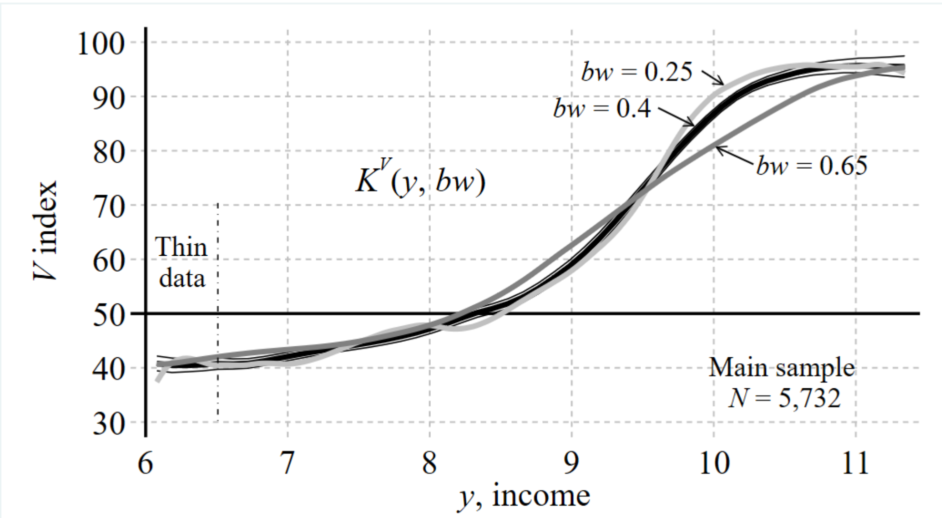


Figure A1.3

$V(y) \approx K^V(y, bw)$

For three *bw*'s



A2 (Ar) The reverse $y = y(X)$ transition curves

Figure A2 reports (Ar) the reverse curve from Figure 2 and compares it with the democratic transition (A) from section A1. The Ar-curves have a narrow range on the y-axis [8, 10], and in the interval [0, 70] on the X-axis the relation explains nothing. The transition curve has a substantial range on both axes. See also section 4.2.

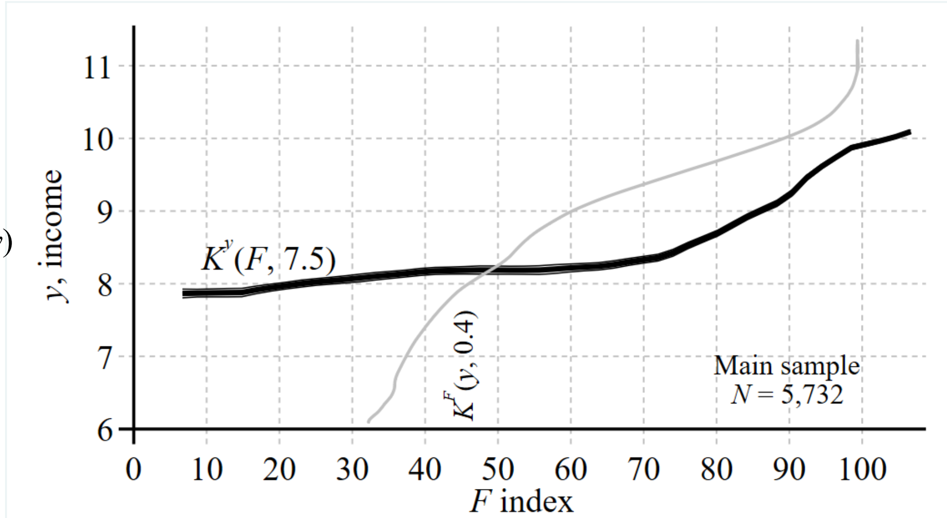


Figure A2.1
$y(F) \approx K^y(F, bw)$
and $F(y) \approx K^F(y, bw)$
from Figure A1.1

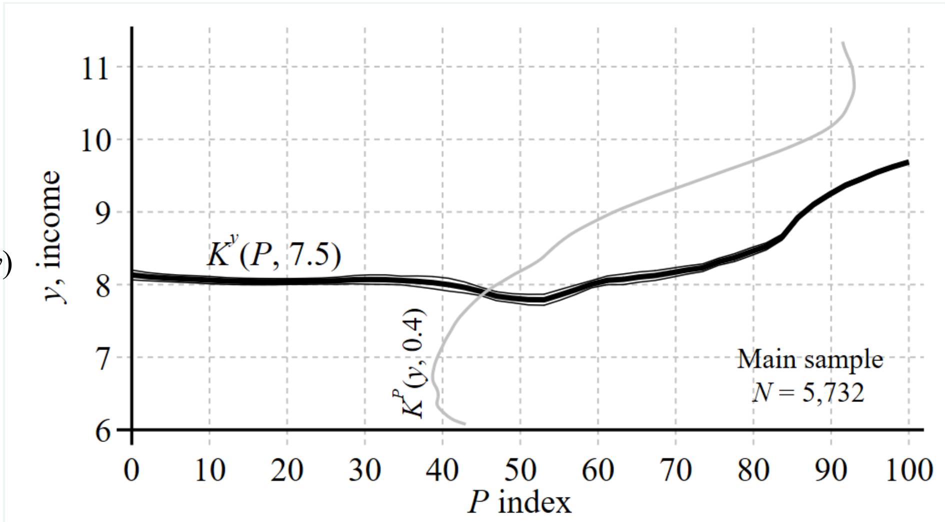


Figure A2.2
$y(P) \approx K^y(P, bw)$
and $P(y) \approx K^P(y, bw)$
from Figure A1.2

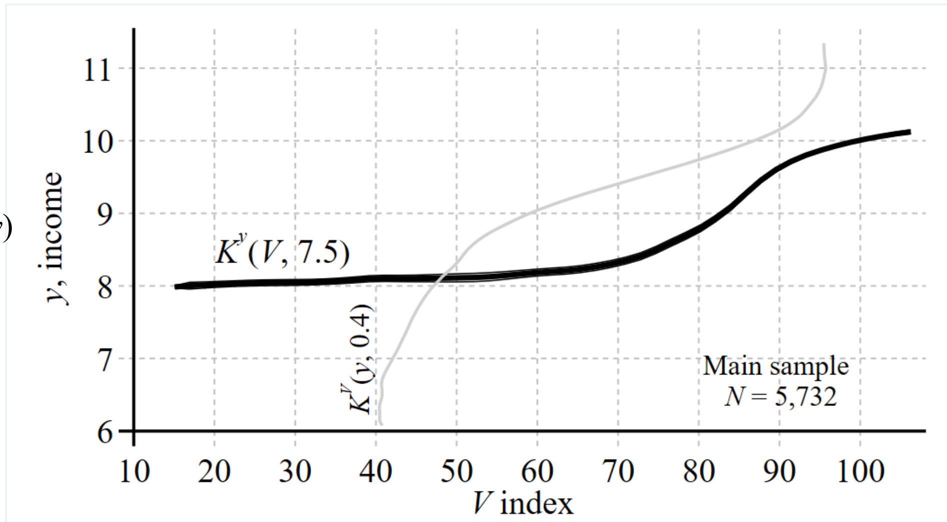


Figure A2.3
$y(V) \approx K^y(V, bw)$
and $V(y) \approx K^V(y, bw)$
from Figure A1.3

A3 (A) and (Ar) curves for long series: The P and the V indices

The P and V-indices have series back to 1800. The 29 countries listed in Table A3.2 have the longest time series for the (P, y)-series, and the 33 in Table A3.2 have the longest (V, y) series. All series end in 2018. Both samples have too many western countries. To widen the sample for the P-graph two Latin American OPEC countries, Ecuador, and Venezuela, are included.

Table A3.1 The long (P, y)-series. N = 4,925

Nr	Country	*N*	Start	Span	Nr	Country	*N*	Start	Span
1	Argentina	147	1850	169	16	Mexico	116	1850	169
2	*Austria*	146	1820	199	17	*Netherlands*	199	1815	204
3	*Belgium*	167	1846	173	18	*New Zealand*	150	1860	159
4	Bolivia	130	1846	173	19	*Norway*	185	1820	199
5	Brazil	168	1850	169	20	Peru	195	1821	198
6	*Canada*	149	1870	149	21	*Portugal*	193	1800	219
7	Chile	177	1818	201	22	Romania	150	1864	155
8	Colombia	146	1850	169	23	*Spain*	175	1805	214
9	*Denmark*	193	1820	199	24	*Sweden*	218	1800	219
10	Ecuador	120	1870	149	25	*Switzerland*	168	1851	168
11	*France*	199	1820	199	26	*UK*	219	1800	219
12	*Germany*	167	1820	199	27	Uruguay	127	1850	169
13	*Greece*	177	1833	186	28	*USA*	219	1800	219
14	*Italy*	202	1815	204	29	Venezuela	189	1830	189
15	Japan	134	1800	219		Average	**169.8**		**188.2**
17 countries in italics are Western. It is 59% of countries and 63% of observations									

Table A3.2. The long (V, y)-series. N = 5,675

Nr	Country	*N*	Start	Span	Nr	Country	*N*	Start	Span
1	Argentina	149	1800	219	18	Japan	141	1800	219
2	*Australia*	199	1820	199	19	Mexico	141	1800	219
3	*Austria*	148	1820	199	20	*Netherlands*	213	1800	219
4	*Belgium*	173	1846	173	21	*New Zealand*	150	1860	159
5	Bolivia	130	1846	173	22	*Norway*	190	1820	199
6	Brazil	171	1800	219	23	Peru	192	1821	198
7	*Canada*	151	1850	169	24	Poland	139	1811	208
8	Chile	207	1800	219	25	Portugal	207	1800	219
9	Colombia	152	1820	199	26	Romania	152	1862	157
10	Cuba	123	1829	190	27	Russia	129	1885	134
11	*Denmark*	199	1820	199	28	*Spain*	175	1805	214
12	*Finland*	156	1863	156	29	*Sweden*	219	1800	219
13	*France*	199	1820	199	30	*Switzerland*	168	1851	168
14	*Germany*	167	1800	219	31	*UK*	219	1800	219
15	*Greece*	184	1833	186	32	Uruguay	151	1850	169
16	India	143	1801	218	33	*USA*	219	1800	219
17	*Italy*	219	1800	219		Average	**172.0**		**196.8**
19 countries in italics are Western. It is 58% of countries and 63% of observations									

Figure A3.1. *P*-index long series: A-curve, with Ar-curve included

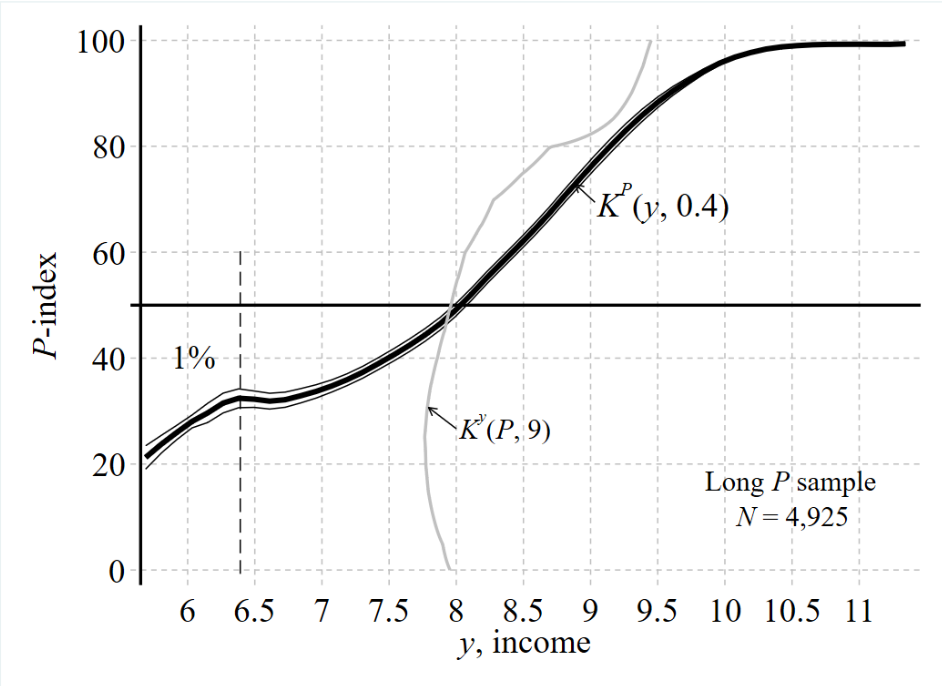


Figure A3.2. *V*-index long series: A-curve, with Ar-curve included

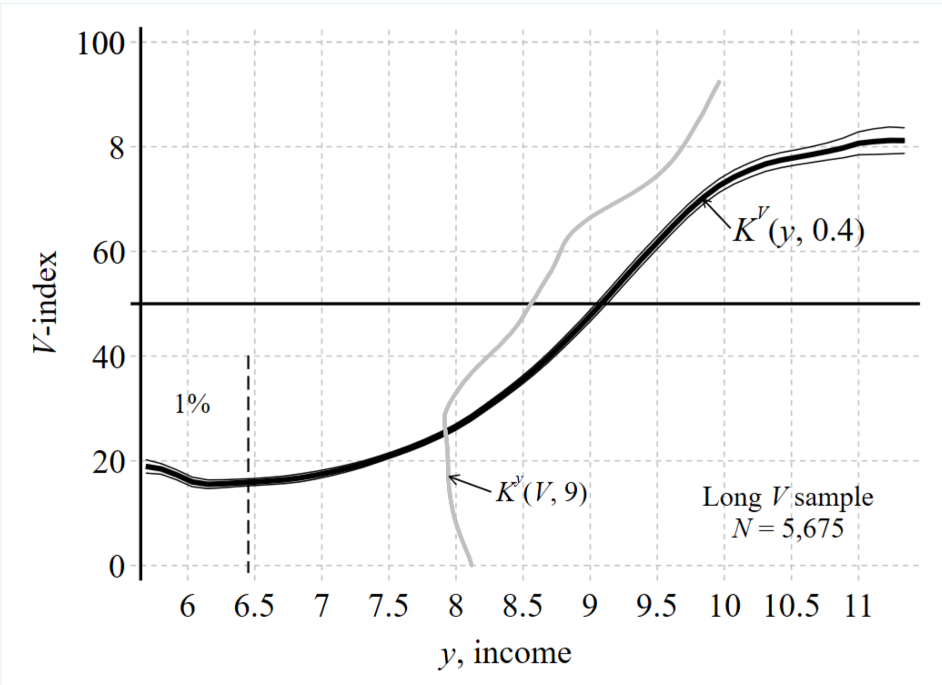


Figure A3.2 uses the new update for the *V*-Dem series that is multiplied by 1000 compared with the previous versions. To get the index into a percentage score it is divided by 10. The *V* series are often longer than the *P* series as they include years under foreign rule and years with no government coded as zero by the *P*-index.

Figures A3.1 and A3.2 show that the A-curves $K^P(y, 0.4)$ and $K^V(y, 0.4)$ look as the corresponding curves in Figure 1. The only deviation is for the leftmost 1% of the observations on Figure A3.1 – all but one of these are for Romania.

The Ar-curves included are also like the corresponding curves in Figure 2. They have a range on the income axis of 2 income points, so they show very little.

The correlations between X and y in the main sample and in the two long samples are quite similar as seen in Table A3.3. The samples are different, so the fact that the correlations in the long samples are a little larger is not important.

Table A3.3. Correlations the Main sample and in the two long samples

	$r(P, y)$	N	$r(V, y)$	N
Main sample	0.569	5,668	0.682	5,668
Long samples	0.681	4,925	0.705	5,675

A4 The dX(y) curves. First difference to the A-relation

Figure 1 showed how the democratic transition should look, and Figure 2 fully confirmed the theory, sections A1 and A3 showed that these figures are rather robust. Figure 1a also included a gray curve showing how it should look when the explained variable is in first differences. Figure A4 shows the three $dX = dX(y)$ curves.

Figure A4.1

$dF(y) \approx K^{dF}(y, bw)$

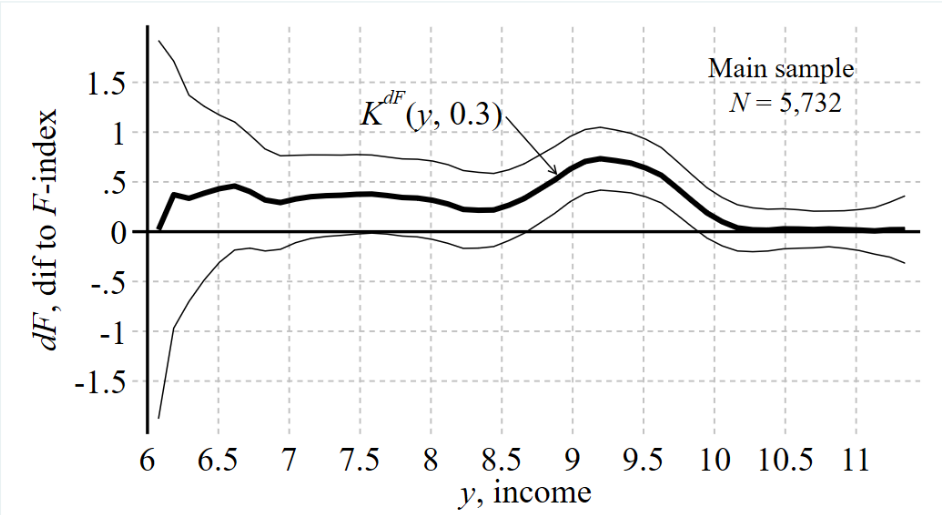


Figure A4.2

$dP(y) \approx K^{dP}(y, bw)$

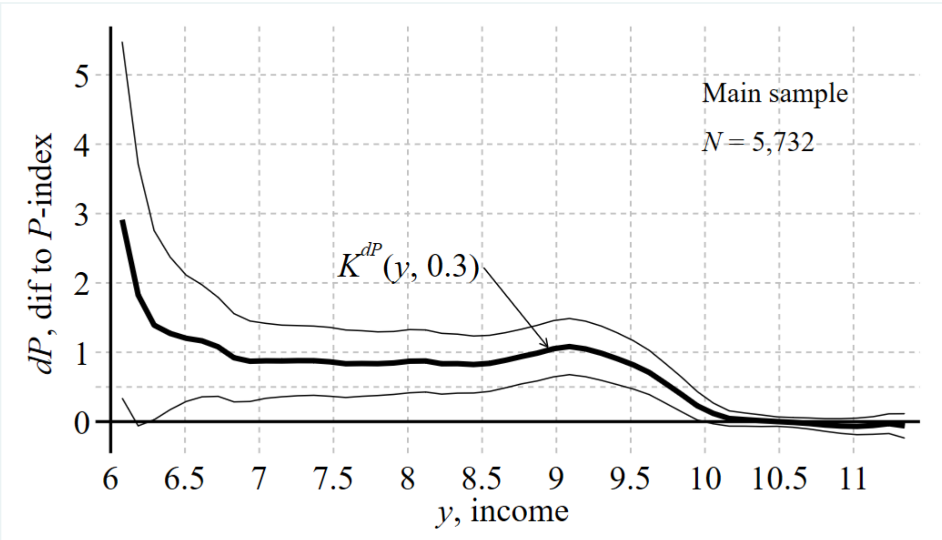


Figure p.3

$dV(y) \approx K^{dV}(y, bw)$

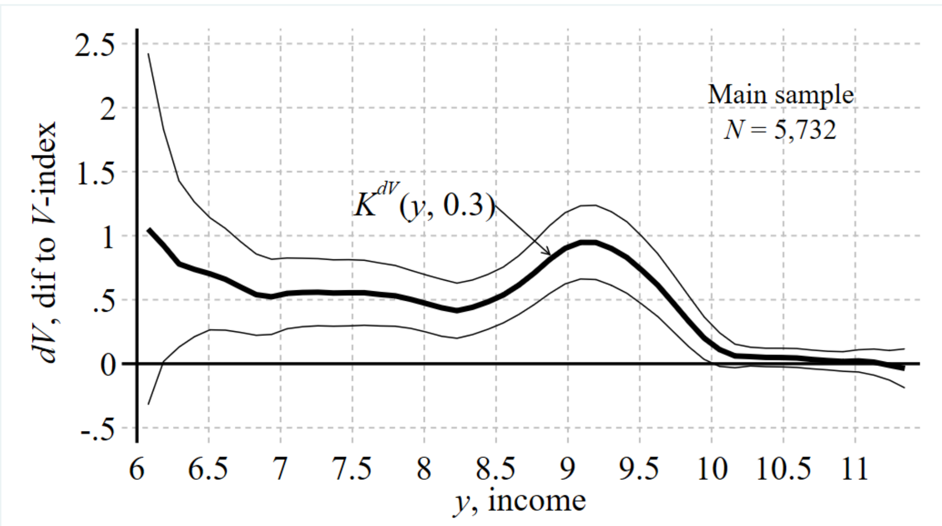


Table A4. Descriptive regressions related to Figure A4

Sample	Variable	Regression: $dX = ay + b$, where $dX = dF, dP, dV$ dF	dP	dV
All	y, income	-0.044 (-0.6)	-0.256 (-2.9)	-0.111 (-2.2)
N = 5,732	Constant	0.725 (1.1)	2.945 (3.8)	1.468 (3.3)
	R^2	0.000	0.002	0.001

See note to Table 5.

The three curves are drawn with the same range (3 pp) at the vertical axis, but it is shifted a bit. All three curves have a hump between 9 and 9.5 where the transition is fastest. This is late in the grand transition. Thus, first countries grow a great deal, and then democracy comes about. Not the other way as suggested by the B-theory.

Consequently, Figure A4 is not a full confirmation of the prediction on Figure 1a. The three graphs do have a hump, but it is weak. The political system does stabilize at high income. But the fit of the three $dX = dX(y)$ relations in Table A4 is very poor, and while the three curves on Figure A4 looks similar the regressions in Table A4 differ.

A5 (B) The g = g(X) relations with ci's and bw experiments

This section uses the *gT* sample, where growth truncated to be in the interval [-10, 12]. The figures for *F* and *V* have a significant kink after $X = 85$. The *P*-index might also have such a kink, but it is insignificant.

Figure A5.1.
$g(F) \approx K^g(F, bw)$

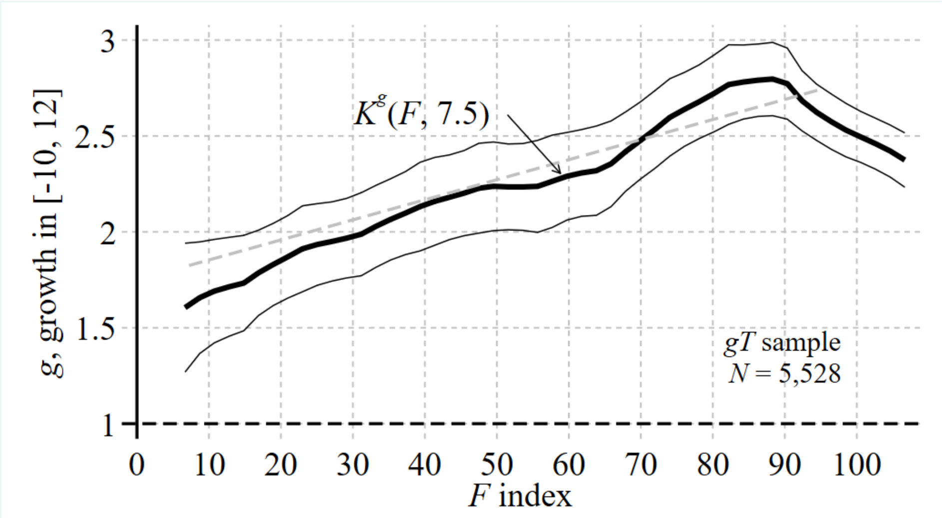


Figure A5.2.
$g(P) \approx K^g(P, bw)$

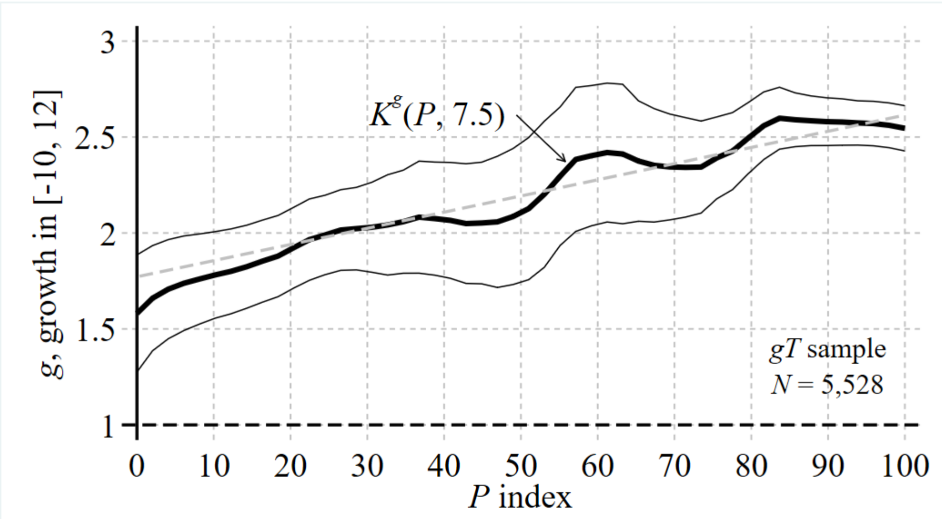
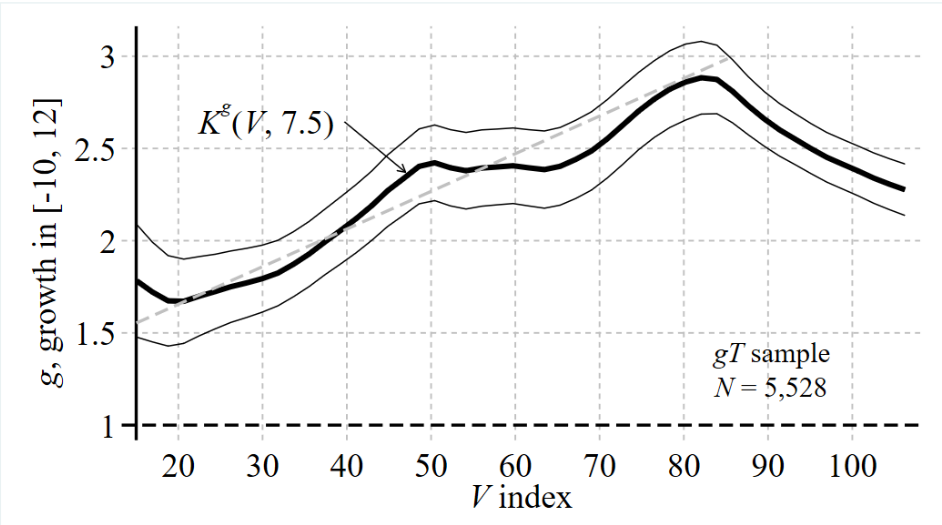


Figure A5.3.
$g(V) \approx K^g(V, bw)$



The three curves above are now calculated for 4 bandwidth 5, 7, 9 and 11. It is now clear that also the P-index has a downward bend for high values of the index.

Figure A5.4.
$g(F) \approx K^g(F, bw)$
$bw = 5, 7, 9, 11$

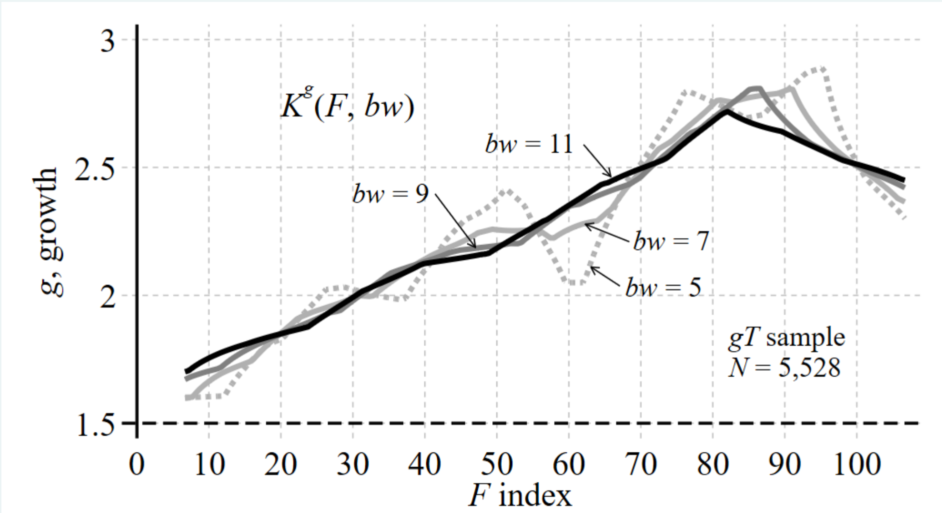


Figure A5.5.
$g(P) \approx K^g(P, bw)$
$bw = 5, 7, 9, 11$

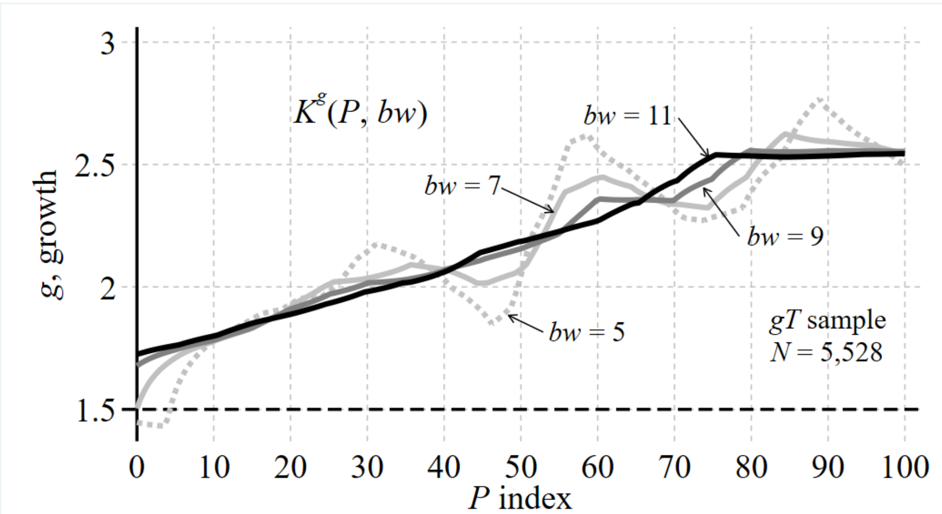
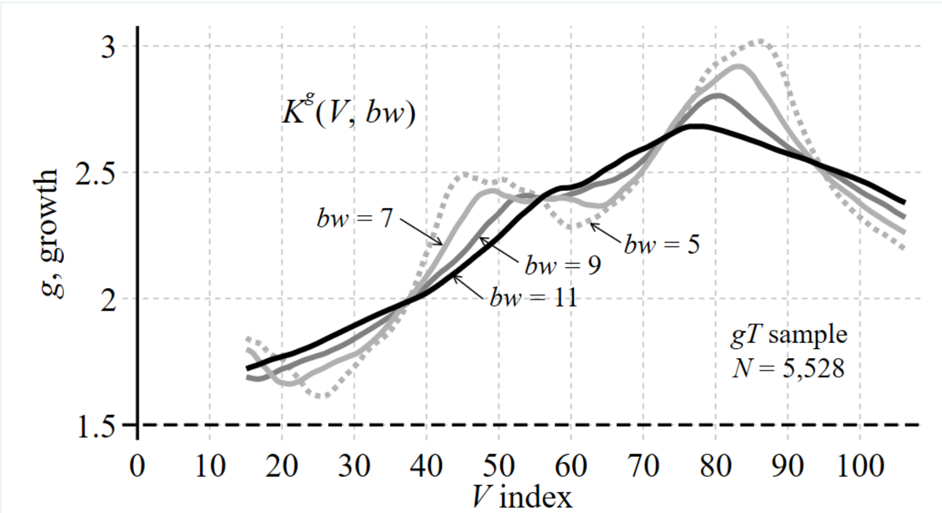


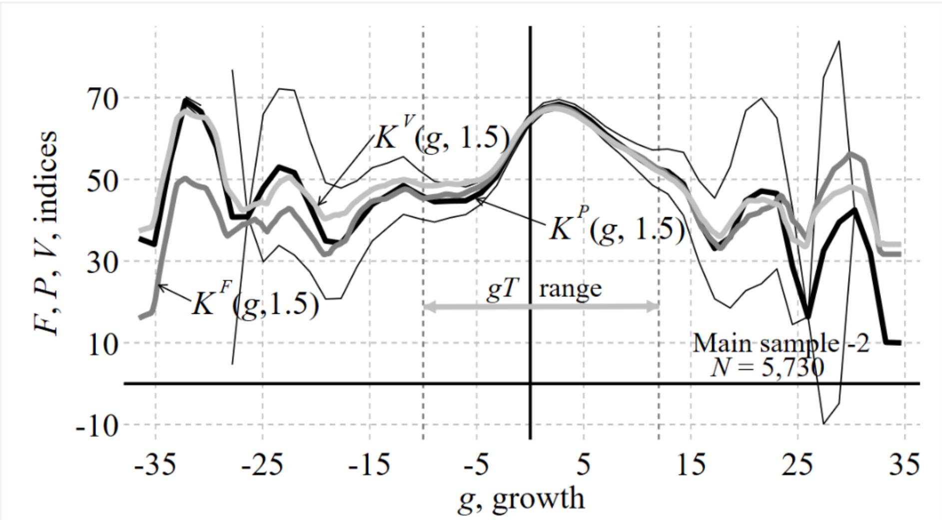
Figure A5.6.
$g(V) \approx K^g(V, bw)$
$bw = 5, 7, 9, 11$



A6 (Br) Three X = X(g) relations

The Br-curves for the truncated *gT* sample is shown as Figure 5 in the main paper. Figure A6.1 shows the curves for the main sample. Outside the *gT*-range the curves turn quite wild and the confidence intervals rise substantially. For positive *g*'s the slope is negative..

Figure A6.1. Br-curves: The three *X*-indices explained by *g*.



The confidence intervals shown are for the *P*-curve. Two extreme g observations omitted

Figure A6.2. Comparing (B) and (Br)

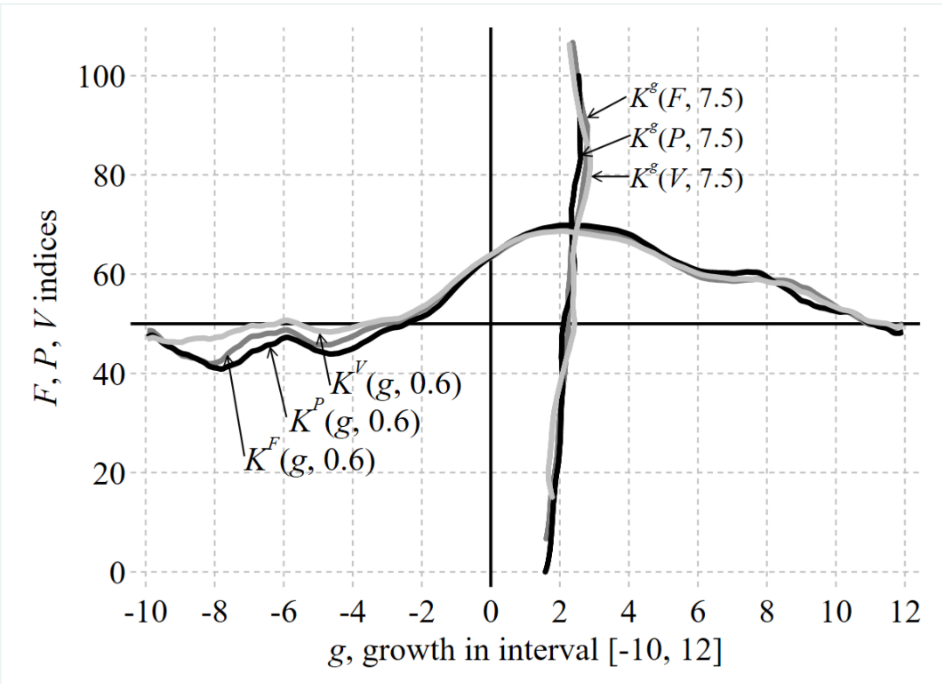


Figure A6.2 shows B-relation from Figure 4b and the Br-relation from Figure 5 (the *gT* sample from Figure 6.1) together. The two relations are almost orthogonal as expected when the correlations are 0.08, see section A9. While the B-relation is explained by the p-o-i theory in section 4.3, it is not so easy to explain the highly significant hump-shaped Br-relation. Perhaps the most important finding about the Br-relation is that the range of *X* explained by the range of *g* is from 40 to 70, where 70 occurs for about 2% growth.

Table A6. Descriptive regressions related to Figures 5 and A6.1. *gT* sample

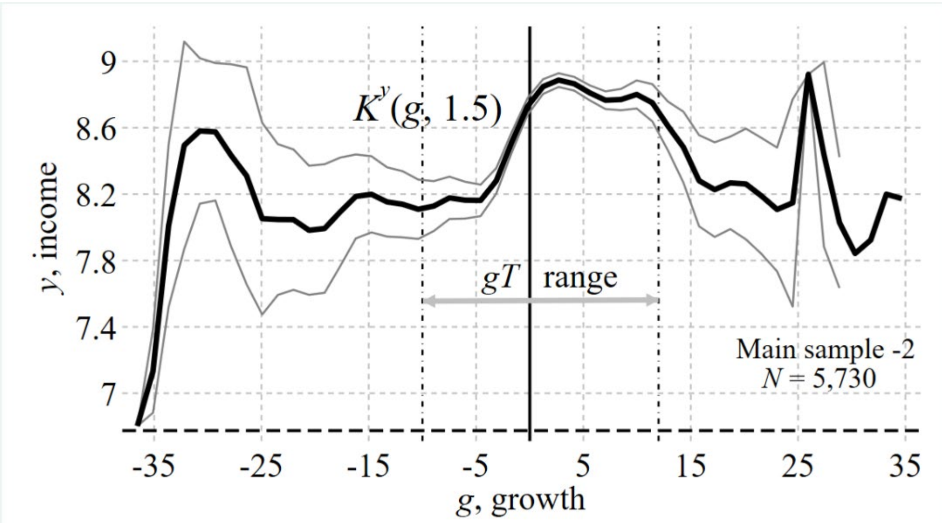
Explained	By	*F*	*P*	*V*
X index	*g*, Growth	0.673 (5.5)	0.829 (6.4)	0.533 (5.1)
(5,732)	Constant	60.90 (115.0)	60.70 (107.6)	61.21 (134.3)
	R^2	0.006	0.007	0.005
X index	*g*, growth	1.485 (10.9)	1.707 (11.7)	1.277 (10.9)
(5,528)	g^2, squared	-0.256 (-12.4)	-0.277 (-12.6)	-0.234 (-13.2)
	Constant	63.91 (110.9)	63.96 (104.2)	63.97 (129.1)
	R^2	0.032	0.035	0.035

Table A6 reports the regressions related to Figure 6.1. This is also Neither (B) nor (Br) explains very much, but the squared term in the second part of the table helps a little.

A7 The robustness of (L) and (Lr) to bw and to country averages

Figure A7.1 shows the Lr-curve for all *g*-observations. The number of observations outside the *gT*-range is small Thus the confidence intervals are wide. On the other figures in this section the *g* is limited to the interval [-25, 25]. The L- and Lr-curve are drawn together on Figure A7.2. As the correlation between *y* and *g* is rather small the two curves are almost orthogonal.

Figure A7.1. (Lr) for all growth rates



Two extreme *g* observations omitted

Figure A7.2. Comparing (L) and (Lr)

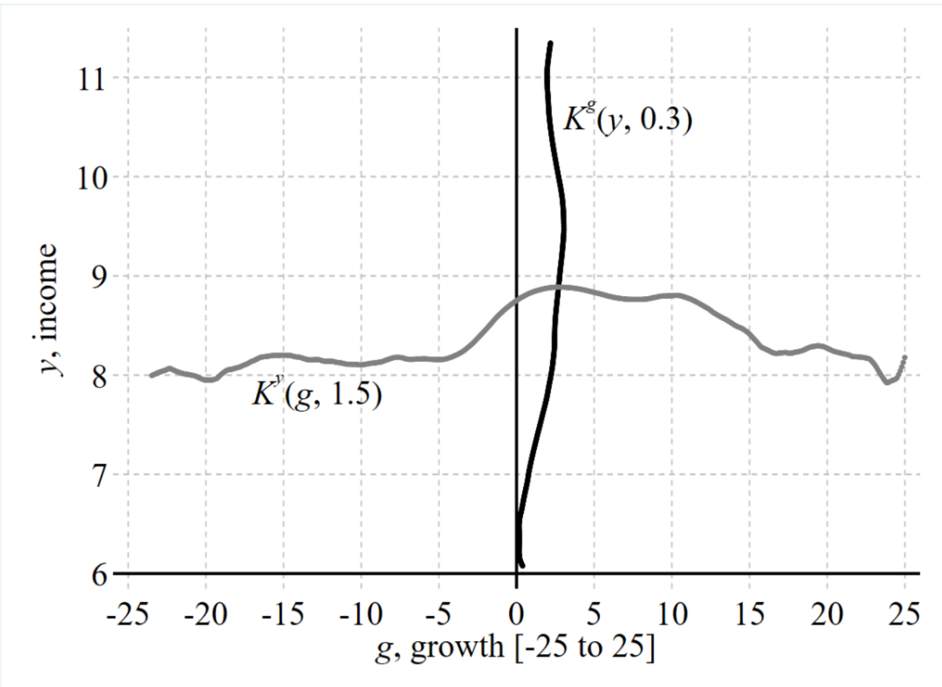


Figure A7.3. The robustness of (L) to the *bw*

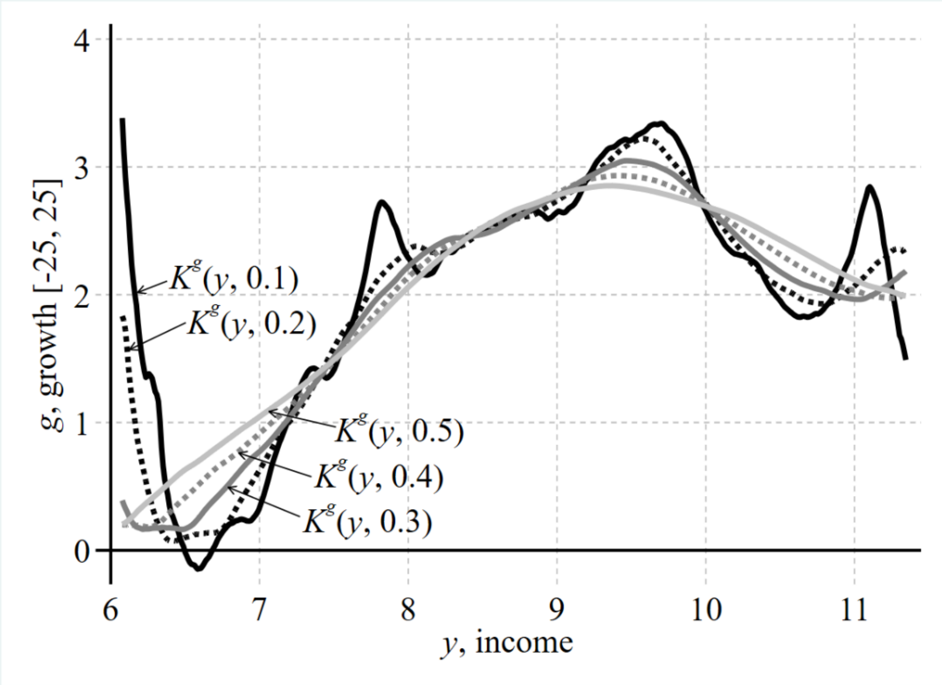
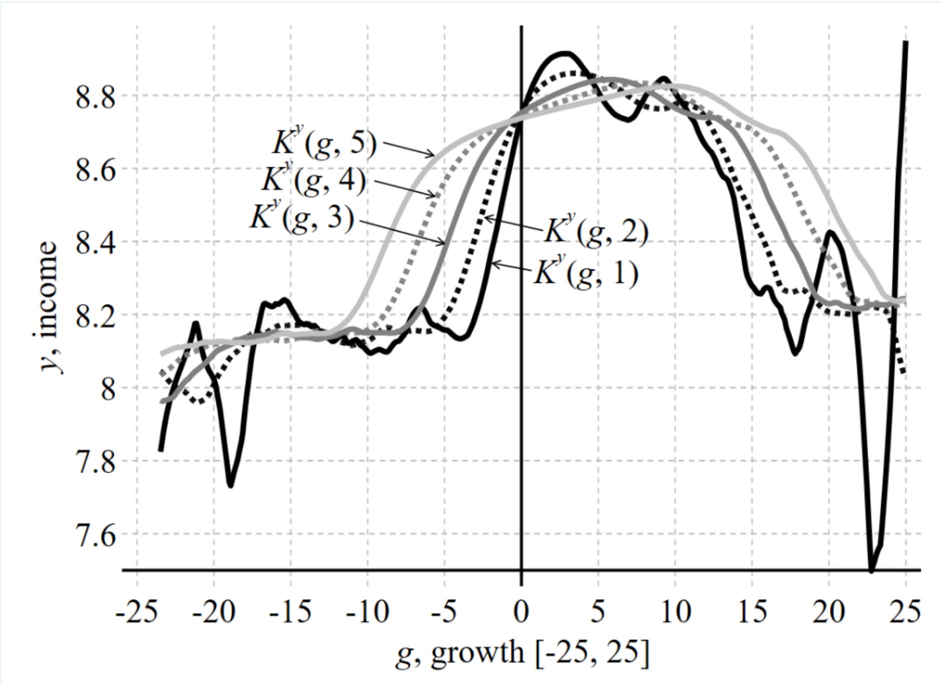


Figure A7.4. The robustness of (Lr) to the bw



(i) The curves on Figure A7.3 are more robust to bw experiments. (ii) The income range on Figure A7.4 is small relative to large variation of *y* in the data, while the variation of *g* on Figure A7.3 covers the range of 90% of the observed values. This supports the argument in the paper that (L) is the obverse and (Lr) is the reverse relation.

Section 10 shows that the cross-country correlation for the 137 country averages between growth and income is 0.366. This is three times larger than the correlation in all 5,668 observations. To check that this result is consistent with the analysis in section 6 of the paper and the analysis above the two cross-country kernel analyses are calculated for the 137 country averages. The two figures should be compared to Figures 5 and 6 in the main paper.

Figure A7.5 looks perfectly as Figure 5 when it is truncated at 6.6 and 10.7. The convergence section of the curve on Figure A7.5 has a dubiously negative slope. It is however significantly lower than slope of the divergence part of the curve. In addition, the bend of the curve is a little below 9.5 at both graphs.

Figure A7.6 also looks as Figure 6. It has the same strong positive slope for negative growth rates, but it ceases for *g* just above 0.5, where it gives an unclear result.

Figure A7.5. The robustness of (L) the transition of the growth rate to country averages

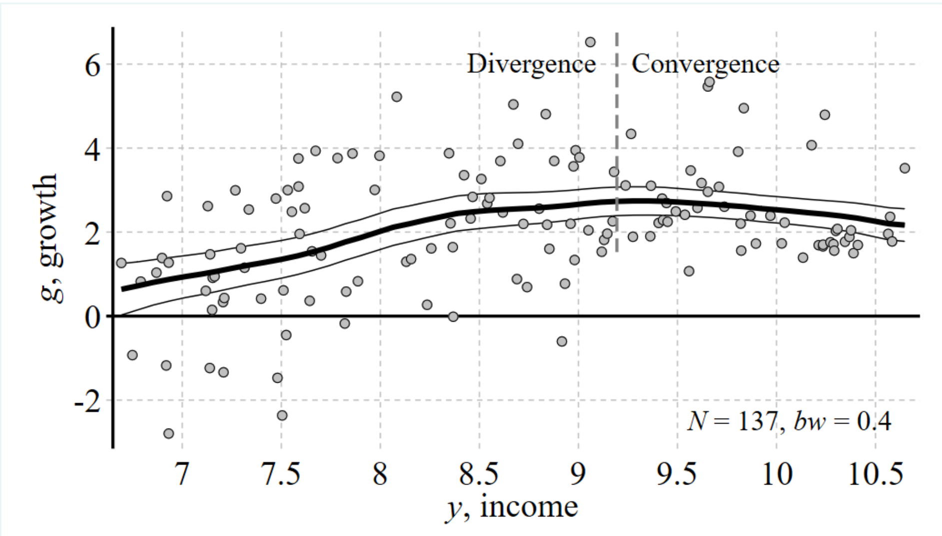
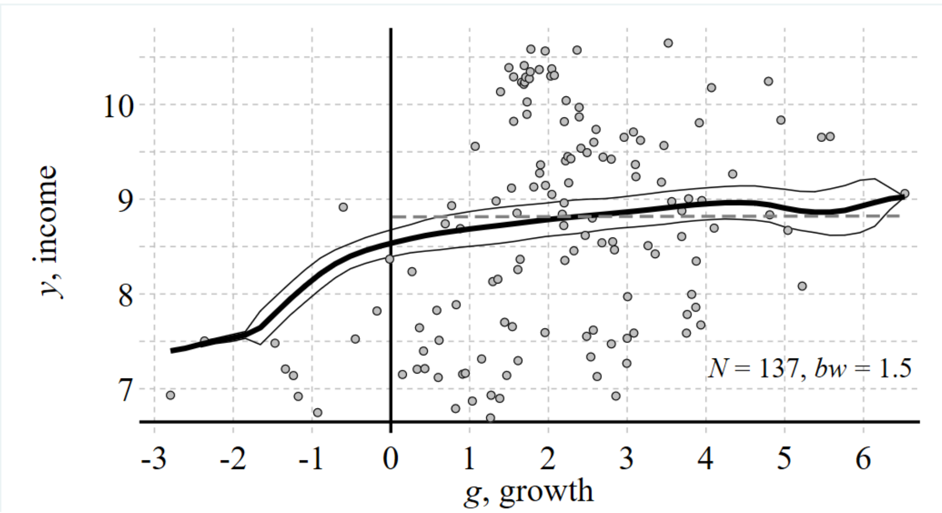


Figure A7.6. The robustness of (Lr) to country averages



A8 Autocorrelation in the g-series

The discussion of the relation from the political regime to the growth rate needs information about the inertia in the growth rate. It is analyzed in Table A8 and Figure A8. The correlations given are calculated for each country in isolation and averaged.

Table A8. Autocorrelations in the growth rates

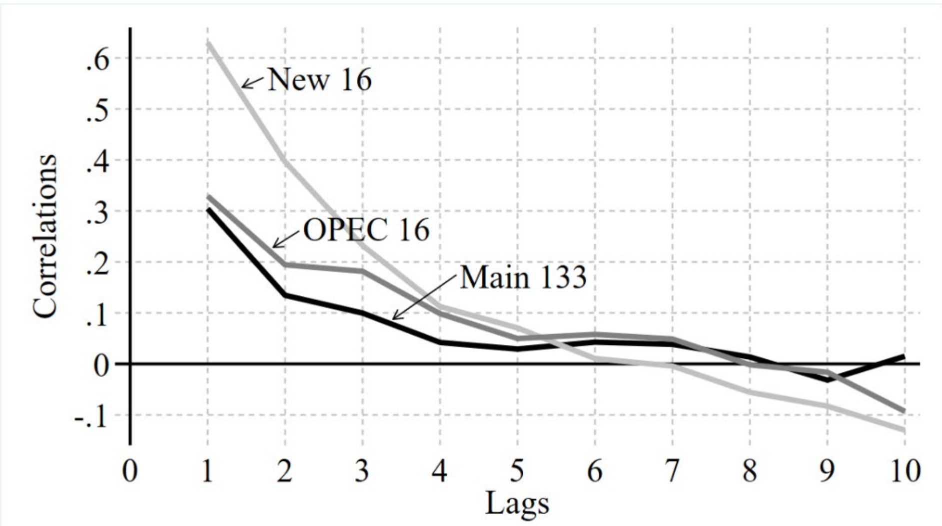
Lags	Group	1	2	3	4	5	6	7	8	9	10
(1)	Main	0.305	0.135	0.100	0.042	0.029	0.043	0.038	0.013	-0.032	0.015
(2)	New	0.630	0.396	0.232	0.113	0.071	0.011	-0.004	-0.056	-0.083	-0.130
(3)	OPEC	0.329	0.194	0.182	0.098	0.050	0.058	0.049	-0.002	-0.016	-0.093

(1) Main group: 133 countries with data every year from 1972 to 2018.

(2) New group: 16 countries starting 1981 or later.

(3) OPEC group: 16 OPEC countries.

Figure A8. Three autocorrelation functions for the growth rate



14 of the new countries in group 2 are the result of the dissolution of the USSR and Yugoslavia. These countries started with strong crises and later had strong recuperations, so they have unusually high autocorrelation for the first lags.

A9 Correlations as Table 3 for the two truncated samples

The two tables are close to Table 3. Recall that the three correlations α, β, and λ should explain (A) or (Ar), (B) or (Br), and (L) or (Lr), respectively.

Table A9.1a. Correlations for the *gT* sample, *N* = 5,528

		Pearson's correlation, *r*							Spearman's rank correlation, *ρ*						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		y	*g*	*F*	*P*	*V*	*dF*	*dP*	*y*	*g*	*F*	*P*	*V*	*dF*	*dP*
(2)	*g*	**0.14**							**0.12**						
(3)	*F*	**0.66**	**0.07**						**0.67**	**0.05**					
(4)	*P*	**0.55**	**0.09**	0.90					**0.63**	**0.06**	0.92				
(5)	*V*	**0.66**	**0.07**	0.93	0.90				**0.66**	**0.05**	0.92	0.93			
(6)	*dF*	-0.01	0.01	0.10	0.07	0.02			-0.01	0.01	0.08	0.03	0.01		
(7)	*dP*	-0.04	-0.02	0.02	0.08	-0.03	0.53		-0.07	-0.03	-0.02	0.02	-0.04	0.32	
(8)	*dV*	-0.03	-0.02	0.06	0.08	0.06	0.46	0.44	-0.03	-0.02	0.03	0.02	0.02	0.21	0.24

Table A9.1b. Condensed version of Table A9.1a

		Pearson's, *r*				Spearman's, *ρ*			
		(1)	(2)	(3)-(5)		(1)	(2)	(3)-(5)	
		y	*g*	*X*	within	*y*	*g*	*X*	within
(2)	*g*	λ, **0.14**				λ, **0.12**			
(3)-(5)	*X*	α, **0.62**	β, **0.08**		0.91	α, **0.65**	β, **0.05**		0.92
(6)-(8)	*dX*	-0.03	-0.01		0.48	-0.04	-0.01		0.26

Table A9.2a. Correlations for the *yT* sample, *N* = 4,461

		Pearson's correlation, *r*							Spearman's rank correlation, *ρ*						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		y	*g*	*F*	*P*	*V*	*dF*	*dP*	*y*	*g*	*F*	*P*	*V*	*dF*	*dP*
(2)	*g*	**0.22**							**0.22**						
(3)	*F*	**0.50**	**0.12**						**0.50**	**0.12**					
(4)	*P*	**0.41**	**0.12**	0.88					**0.45**	**0.13**	0.88				
(5)	*V*	**0.49**	**0.12**	0.90	0.88				**0.46**	**0.12**	0.88	0.90			
(6)	*dF*	0.01	0.00	0.13	0.08	0.04			0.01	0.01	0.12	0.05	0.03		
(7)	*dP*	-0.01	-0.02	0.05	0.11	-0.01	0.54		-0.03	-0.04	0.03	0.07	-0.00	0.33	
(8)	*dV*	0.00	-0.03	0.10	0.11	0.11	0.46	0.44	-0.00	-0.03	0.07	0.05	0.06	0.24	0.26

Table A9.2b. Condensed version of Table A9.2a

		Pearson's, *r*				Spearman's, *ρ*			
		(1)	(2)	(3)-(5)		(1)	(2)	(3)-(5)	
		y	*g*	*X*	within	*y*	*g*	*X*	within
(2)	*g*	λ, **0.22**				λ, **0.22**			
(3)-(5)	*X*	α, **0.47**	β, **0.12**		0.89	α, **0.47**	β, **0.12**		0.89
(6)-(8)	*dX*	0.00	-0.01		0.48	-0.01	-0.01		0.28

A10 Between and within country correlation

The main correlations from Table 2 of the main paper are repeated in row (1) of Table A10, which expands the correlations with the between country and the within country correlations.

Table A10. Correlations for all data, and within and between countries

	All N = 5,668	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		For y and $X = F, P, V$			For g and $X = F, P, V$			For g
		$r(y, F)$	$r(y, P)$	$r(y, V)$	$r(g, F)$	$r(g, P)$	$r(g, V)$	$r(g, y)$
	Section in main paper	4 (A)			5 (B)			6 (L)
	Unified data	One correlation on all (N = 5,668) as in main paper						
(i)	Table 3 rows (4) and (5)	0.671	0.569	0.682	0.079	0.081	0.065	0.122
	Time-series	Within country correlation (137 countries)						
(ii)	Av for countries	0.195	0.314	0.404	0.069	0.087	0.040	0.093
	(t-ratio)	(4.6)	(7.0)	(9.5)	(3.0)	(3.6)	(1.6)	(3.1)
	Cross-country	Between countries correlation (46 years)						
(iii)	Country averages	0.747	0.671	0.762	0.152	0.126	0.116	0.366
(iv)	Av for cross-country	0.666	0.555	0.677	0.049	0.036	0.025	0.108
	(t-ratio)	(86)	(36)	(79)	(1.9)	(1.5)	(1.0)	(4.2)

The four correlations are done as follows: (i) One regression for all observations. (ii) One correlation for the time series of each of the 137 countries. The arithmetic average is reported, with its t-ratio for the average correlation being zero. It is rejected in all cases except column (6). (iii) One correlation for the 137 country averages. (iv) One cross-country correlation is calculated for the observations from each of the 46 years. The arithmetic is reported, with its t-ratio for the average correlation being zero. It is rejected for five results, but not for column (5) and (6).

It would be nice if the table showed that the results reported in Table 3 are represent-tative, and it is almost true especially for columns (1) to (3), where the correlations in rows (i), (iii) and (iv), giving the effect of the democratic transition, are similar. The correlations in row (ii) are smaller. The time series are too short to show the full transition. Table A3.3 in section A3 that shows that the correlations in the long time series is the same as in the main sample.

Columns (4) to (6) confirm that the relation between g and X is relatively volatile, and often insignificant. Column (7) shows the data giving the transition in the growth rate. Here the cross-country correlation is rather high, but as shown in section A7 it gives similar kernels.

Figures A10.1 to 3 show the path 7 annual cross-country correlations with the averages reported in row (4). They give two very different pictures. The three (y, X) correlations are amazingly stable over the 46 years. It is no wonder that the t-ratios for these correlations are so high. The three (g, X) correlations are quite volatile, but they track each other rather well. In Table A10 the averages are of dubious significance. Figure A10.3 show that the main reason for the volatility of r(X, g) is the volatility of r(y, g). The curves on Figure A10.2 and the curve on A10.3 does have a great deal in common.

Figure A10.1. The annual correlation of y and $X = F$, P, and V

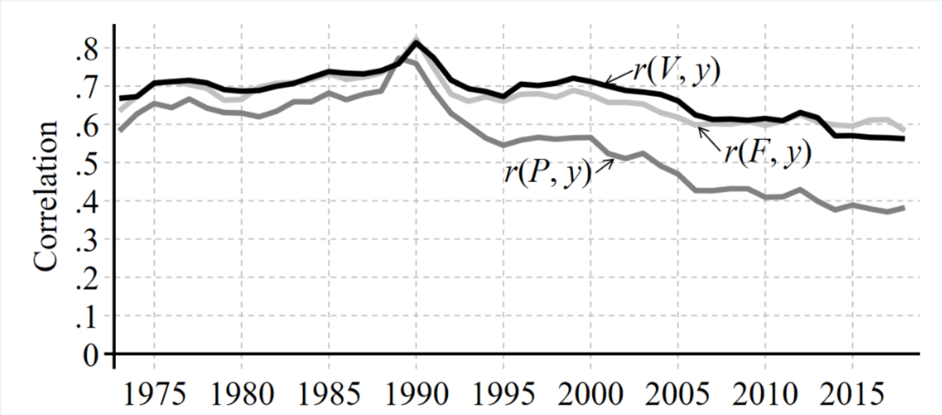


Figure A10.2. The correlation of g and $X = F$, P, and V

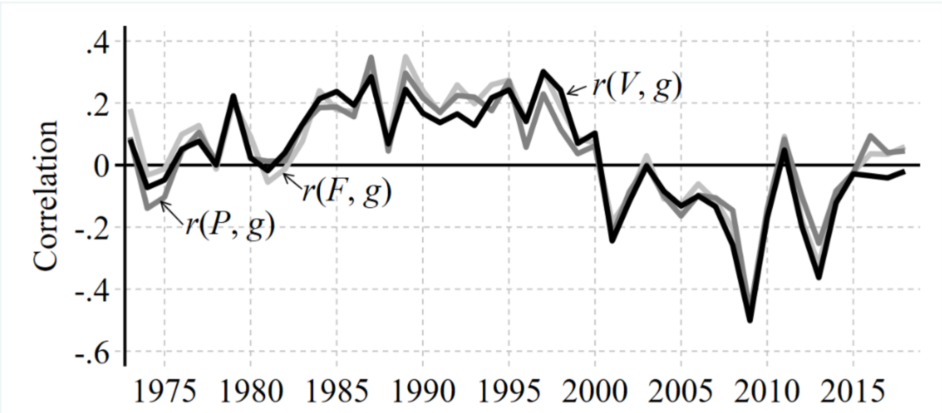
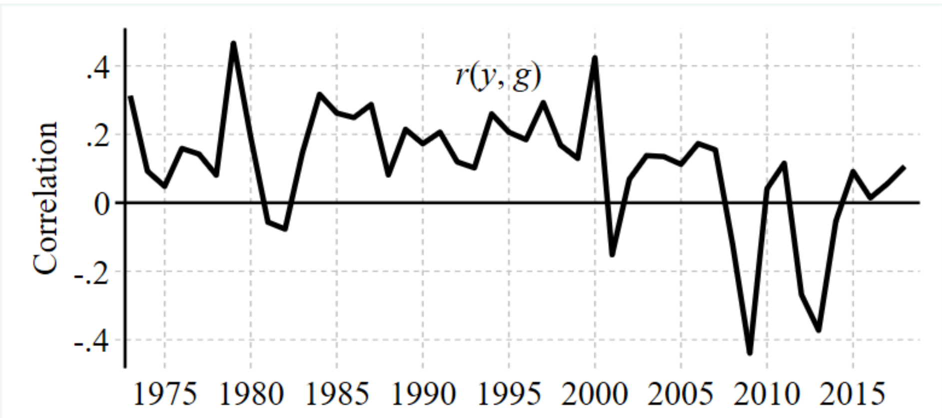


Figure A10.3. The correlation of g and y



A11 The distribution of the eight series, using probit diagrams

Income is almost normally distributed, but growth rates have long tails of extreme values. They are deleted in the *gT* sample. Thus, when *g* enters in an analysis, it is repeated on the *gT* sample, to see if the results hinge on the extreme values.

Two national accounts series: y and $g \approx dy$. $N = 5{,}732$

Figure A11.1. Income, y

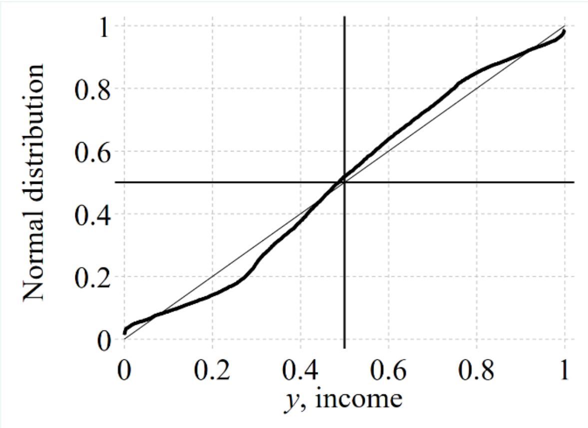
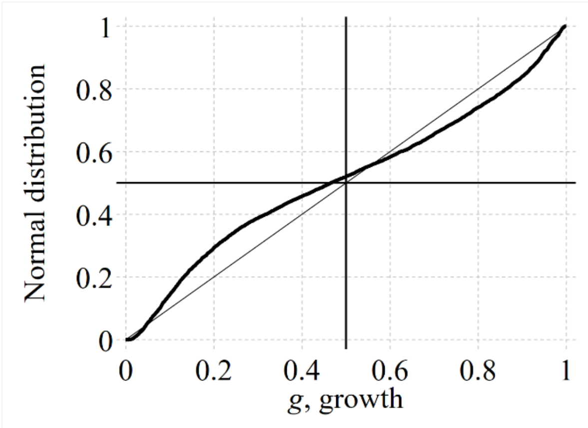


Figure A11.2. Growth, g



Three democracy indices: F, P, and V. $N = 5{,}732$

Figure A11.3. Freedom House, F

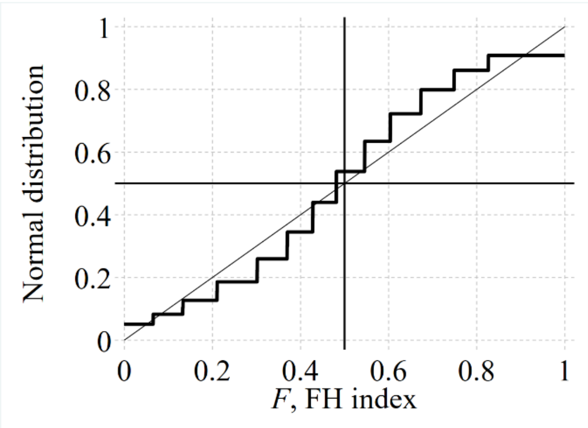


Figure A11.4. Polity, P

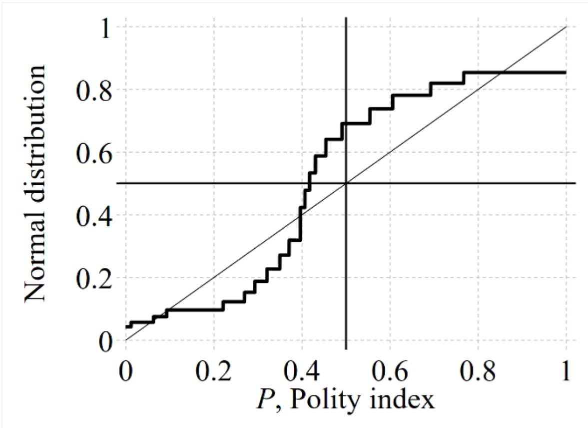
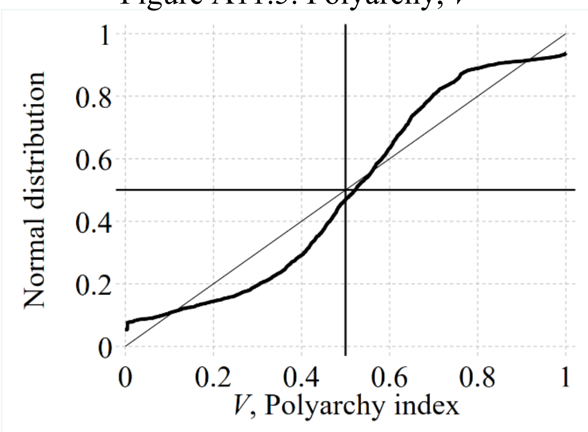


Figure A11.5. Polyarchy, V



The probit diagrams for the democracy indices all bend the opposite way of the growth rate indicating that these indices have a two-topped distribution with a clear peak at the top and close to the bottom. The Freedom House index is the least two-topped, Polyarchy is in between, while Polity is most two-topped. Thus, Polity is the least normal index, see Table 3 and section A9. In addition, the diagrams for FH and Polity are step curves as they are reported as integers, while the V-index is given with 2 to three decimals.

First differences to the three democracy indices: *dF*, *dP*, and *dV*. *N = 5,732*

Figure A11.6. Difference to *F*-index, *dF*

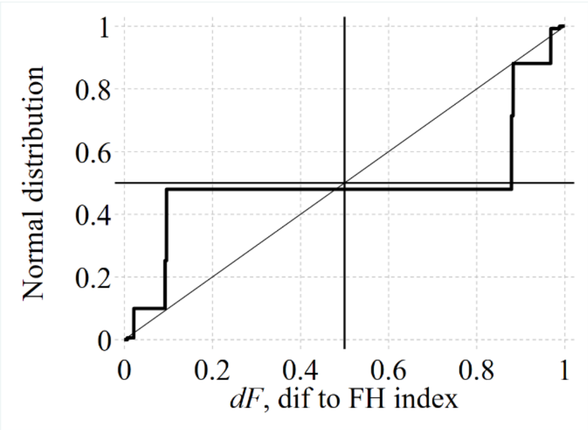


Figure A11.7. Difference to *P*-index, *dP*

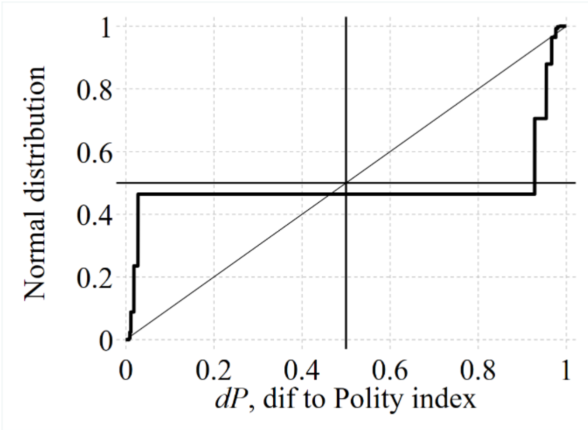
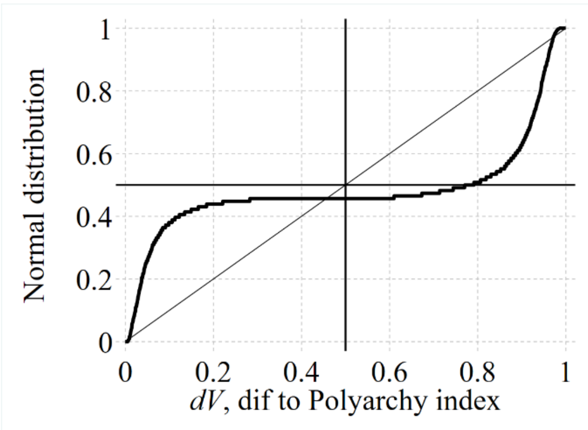


Figure A11.8. Difference to *V*-index, *dV*



The differences to the democracy indices have the same characteristic form with a wide flat section in the middle, for periods where the indices do not change, i.e., where the political system is stable. The flat section is always below the 50% line, thus, there are more positive than negative changes, as there should give the transitions.

The three standard tests for normality in stata all reject normality for all eight series with a wide margin.