



Sahil Chinoy • Nov 12, 2018  
gfx



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# The Cube Root Law

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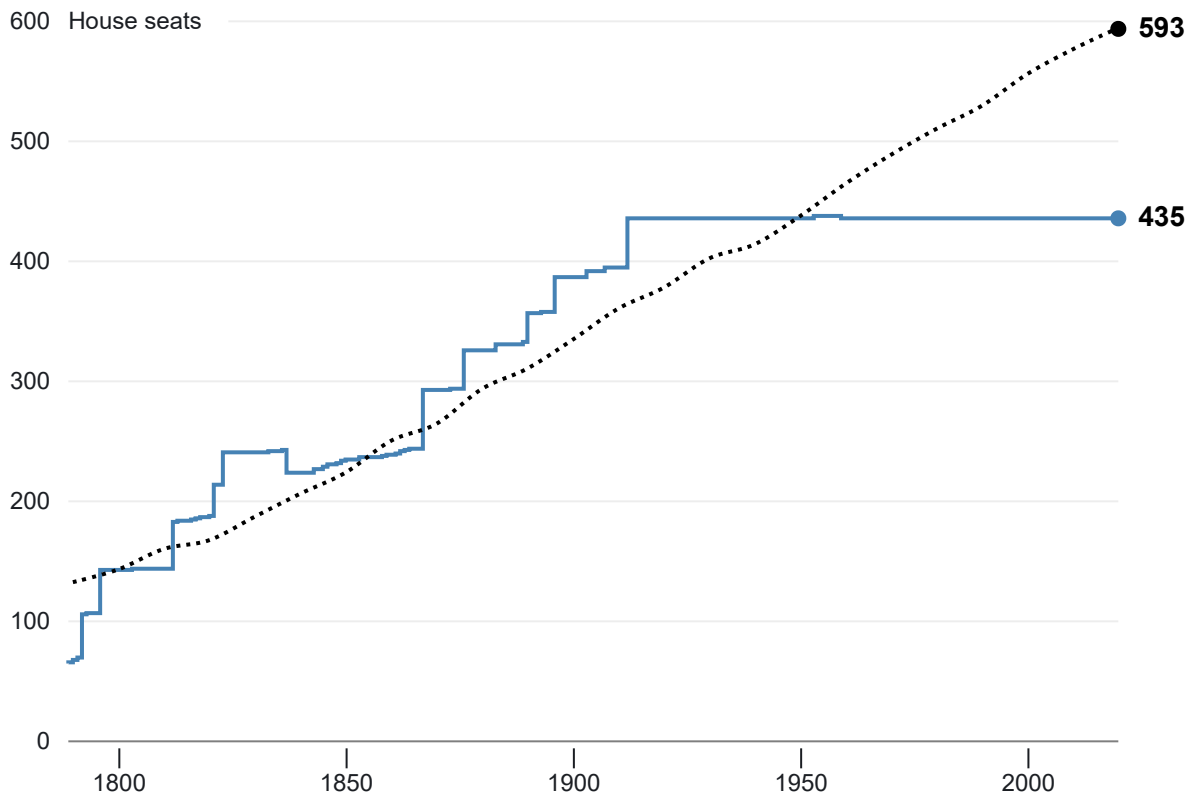
For a [New York Times](#) editorial about expanding the size of the House.

According to [a model](#) proposed by political scientist Rein Taagepera in 1972, the size of a country's legislature roughly tracks the cube root of its population. This implies that the size of the House should be (dashed line) about the cube root of the population minus the size of the Senate.

Through the 1800s, this relationship roughly held. But since about 1950, the House has been too small for the country. In 2020, the projected U.S. population implies a House with 593 members.

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You have 6 unsaved changes. Fork this notebook to save.

?

```
const margin = 50;
const height = 400;

const svg = d3.select(DOM.svg(width, height))
  .style('font-family', 'sans-serif')
  .style('font-weight', 300)
  .style('font-size', '12px');

const margin = {
  left: 40,
  right: 35,
  bottom: 30,
  top: 10
}

const chartWidth = width - margin.left - margin.right;
const chartHeight = height - margin.top - margin.bottom;

const x = d3.scaleLinear()
  .domain(d3.extent(houseSize.map(d => d.year)))
  .range([0, chartWidth]);

const y = d3.scaleLinear()
  .domain([0, 600])
  .range([chartHeight, 0]);

const chart = svg.append('g')
  .attr('transform', `translate(${margin.left}, ${margin.top})`);

const xAxis = g => g
  .attr("transform", `translate(0, ${chartHeight + 4})`)
  .call(d3.axisBottom(x)
    .tickFormat(d => d)
    .ticks(5)
    .tickSize(10)
  )
  .call(g => g.select(".domain").remove());

const yAxis = g => g
  .call(d3.axisLeft(y).ticks(5))
  .call(g => g.selectAll(".domain, .tick line").remove())
  .call(g => g.select(".tick:last-of-type text").clone()
    .attr("x", 0)
    .style("text-anchor", "start")
    .text('House seats'));
```

```
.style('font-size', '12px')
.style('font-weight', 300)
.call(xAxis);

chart.append('g')
.style('font-size', '12px')
.style('font-weight', 300)
.call(yAxis);

// gridlines

chart.append('g')
.call(d3.axisLeft(y).ticks(5)
  .tickSize(-chartWidth)
  .tickFormat(''))
.call(g => g.select(".domain").remove())
.call(g => g.select('.tick:last-of-type line').attr('x1', 80))
.selectAll('line')
.style('stroke', (d, i) => i !== 0 ? '#ddd' : '#000')
.style('stroke-opacity', .5);

const repsLine = d3.line()
.x(d => x(d.year))
.y(d => y(d.reps))
.curve(d3.curveStepBefore);

chart.append('path')
.datum(houseSize)
.attr('d', repsLine)
.style('stroke', 'steelblue')
.style('stroke-width', '2px')
.style('fill', 'none');

const popLine = d3.line()
.x(d => x(d.year))
.y(d => y(d.reps))
.curve(d3.curveCardinal);

chart.append('path')
.datum(population)
.attr('d', popLine)
.style('stroke', 'black')
.style('stroke-width', '2px')
.style('stroke-dasharray', '2px 3px')
.style('fill', 'none');
```

```

.datum(houseSize[houseSize.length - 1])
.attr('transform', d => `translate(${x(d.year)}, ${y(d.reps)})`)

ann1.append('circle')
.attr('cx', 0)
.attr('cy', 0)
.attr('r', 4)
.style('fill', 'steelblue');

ann1.append('text')
.attr('x', 10)
.attr('y', 4)
.text(d => d.reps.toFixed(0))
.style('font-size', '14px')
.style('font-weight', 600)

const ann2 = chart.append('g')
.datum(population[population.length - 1])
.attr('transform', d => `translate(${x(d.year)}, ${y(d.reps)})`)

ann2.append('circle')
.attr('cx', 0)
.attr('cy', 0)
.attr('r', 4)
.style('fill', '#000');

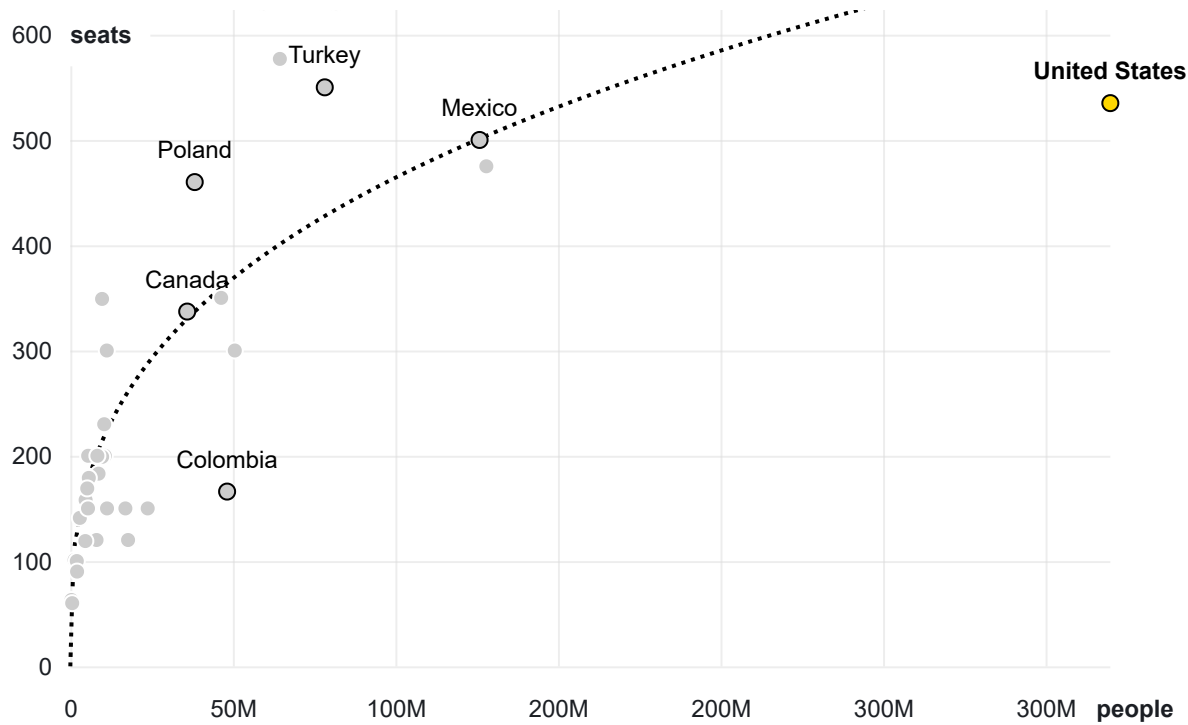
ann2.append('text')
.attr('x', 10)
.attr('y', 4)
.text(d => d.reps.toFixed(0))
.style('font-size', '14px')
.style('font-weight', 600)

return svg.node();
}

```

- + The U.S. is also an outlier compared to other developed nations, which roughly follow the cube root law.

Here are 37 OECD countries. The dashed line is the cube root of the country's population. Note that we are using the *total size* of Congress (535 seats), because the Senate is a more significant lawmaking body than the smaller chambers of other countries.



```

scatter = {
  const width = 600;
  const height = 400;

  const svg = d3.select(DOM.svg(width, height))
    .style('font-family', 'sans-serif')
    .style('font-weight', 300)
    .style('font-size', '12px');

  const margin = {
    left: 40,
    right: 40,
    bottom: 30,
    top: 10
  }

  const chartWidth = width - margin.left - margin.right;
  const chartHeight = height - margin.top - margin.bottom;

  const x = d3.scaleLinear()
    .domain([0, d3.max(oecd.map(d => d.population))])
    .range([0, chartWidth]);

  const y = d3.scaleLinear()
    .domain([0, x.domain()[1] ** (1/3)])
    .range([chartHeight, 0]);

```

```
.attr('transform', `translate(${margin.left}, ${margin.top})`);

const xAxis = g => g
  .attr("transform", `translate(0, ${chartHeight + 4})`)
  .call(d3.axisBottom(x)
    .tickFormat(d3.format('.1s'))
    .ticks(5)
    .tickSize(10)
  )
  .call(g => g.selectAll(".domain, .tick line").remove())
  .call(g => g.select(".tick:last-of-type text").clone()
    .attr("x", 25)
    .style("text-anchor", "start")
    .style('font-weight', 600)
    .text('people'));

const yAxis = g => g
  .call(d3.axisLeft(y).ticks(5))
  .call(g => g.selectAll(".domain, .tick line").remove())
  .call(g => g.select(".tick:last-of-type text").clone()
    .attr("x", 0)
    .style('font-weight', 600)
    .style("text-anchor", "start")
    .text('seats'));

chart.append('g')
  .style('font-size', '12px')
  .style('font-weight', 300)
  .call(xAxis);

chart.append('g')
  .style('font-size', '12px')
  .style('font-weight', 300)
  .call(yAxis);

// gridlines

chart.append('g')
  .call(d3.axisLeft(y).ticks(5)
    .tickSize(-chartWidth)
    .tickFormat(''))
  .call(g => g.select(".domain").remove())
  .call(g => g.select('.tick:last-of-type line').attr('x1', 40))
  .selectAll('line')
  .style('stroke', '#ddd')
```

```
chart.append('g')
.attr("transform", `translate(0, ${chartHeight})`)
.call(d3.axisBottom(x).ticks(5)
  .tickSize(-chartHeight)
  .tickFormat(''))
).call(g => g.select(".domain").remove())
.call(g => g.select('.tick:first-of-type line').attr('y2', -chartHeight + 60))
.selectAll('line')
.style('stroke', '#ddd')
.style('stroke-opacity', .5);

const line = d3.line()
.x(d => x(d))
.y(d => y(d ** (1/3)))
.curve(d3.curveCardinal)

const lineData = d3.range(...x.domain(), 1e6);

chart.append('path')
.datum(lineData)
.attr('d', line)
.style('stroke', '#000')
.style('stroke-width', '2px')
.style('stroke-dasharray', '2px 3px')
.style('fill', 'none')

oecd.find(d => d.country == 'United States').seats = 535;

const countries = chart.append('g')
.selectAll('g')
.data(oecd)
.enter().append('g')
.attr('transform', d => `translate(${x(d.population)}, ${y(d.seats)})`);

const labels = [
  'United States',
  'Mexico',
  'Poland',
  'United Kingdom',
  'Canada',
  'Colombia',
  'Portugal',
  'Turkey',
]
```

```

.attr('cx', 0)
.attr('cy', 0)
.attr('r', 4)
.style('fill', d => d.country == 'United States' ? 'gold' : '#ccc')
.style('stroke', d => labels.includes(d.country) ? '#000' : '#fff')
.append("title")
.text(d => d.country);

countries.filter(d => labels.includes(d.country))
.append('text')
.attr('x', 0)
.attr('y', -12)
.text(d => d.country)
.style('text-anchor', 'middle')
.style('font-weight', d => d.country == 'United States' ? 600 : 300)

return svg.node();
}

```

#### Sources:

- Census population predictions
- OECD's Government at a Glance

oecd = ► Array(37) [Object, Object, Object, Object, Object, Object, Object, Object, Object,

```

oecd = {
  let data =
d3.csv('https://gist.githubusercontent.com/sahilchinoy/c762cc0f3a6cf7a301d18c42355dc0d2
/raw/7d54978e7edb89ca71260b7248999963298f78f3/oecd.csv', d => {
  return {
    country: d.country,
    population: +d.population,
    seats: +d.seats
  }
});

return data;
}

```



1789 64  
1790 65  
1791 67  
1792 69  
1793 105  
1796 106  
1803 142  
1812 143  
1813 182  
1816 183  
1817 184  
1818 185  
1819 186  
1820 186  
1821 187  
1823 213  
1833 240  
1836 241  
1837 242  
1843 223  
1845 226  
1846 228  
1848 230  
1849 231  
1850 233  
1853 234  
1858 236  
1859 237  
1861 238  
1862 239  
1863 241  
1864 242  
1867 243  
1873 292  
1876 293  
1883 325  
1889 330  
1890 332  
1893 356  
1896 357  
1903 386  
1907 391  
1912 394  
1913 435  
1933 435

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```

1953 435
1959 437
1963 435
2020 435`, d => {
  return {
    year: +d.year,
    reps: +d.seats
  }
})

```

```

population = d3.csvParse(`year,people
1790,3929214
1800,5308483
1810,7239881
1820,9638453
1830,12866020
1840,17069453
1850,23191876
1860,31443321
1870,38558371
1880,50189209
1890,62979766
1900,76212168
1910,92228496
1920,106021537
1930,123202624
1940,132164569
1950,151325798
1960,179323175
1970,203302031
1980,226542199
1990,248709873
2000,281421906
2010,308745539
2018,328798286
2020,332639000`, d => {
  return {
    year: +d.year,
    population: +d.people,
    reps: (+d.people) ** (1/3) - 2 * (states.filter(s => s <= d.year).length)
  }
})

```

```

states = d3.csvParse(`StateNo,State,date,Formed from
1,Delaware,"December 7, 1787[8](ratified)",Colony of Delaware[b]
2,Pennsylvania,"December 12, 1787[10](ratified)",Proprietary Province of Pennsylvania
3,New Jersey,"December 18, 1787[11](ratified)",Crown Colony of New Jersey
4,Georgia,"January 2, 1788[8](ratified)",Crown Colony of Georgia
5,Connecticut,"January 9, 1788[12](ratified)",Crown Colony of Connecticut
6,Massachusetts,"February 6, 1788[8](ratified)",Crown Colony of Massachusetts Bay
7,Maryland,"April 28, 1788[8](ratified)",Proprietary Province of Maryland
8,South Carolina,"May 23, 1788[8](ratified)",Crown Colony of South Carolina
9,New Hampshire,"June 21, 1788[8](ratified)",Crown Colony of New Hampshire
10,Virginia,"June 25, 1788[8](ratified)",Crown Colony and Dominion of Virginia
11,New York,"July 26, 1788[13](ratified)",Crown Colony of New York
12,North Carolina,"November 21, 1789[14](ratified)",Crown Colony of North Carolina
13,Rhode Island,"May 29, 1790[8](ratified)",Crown Colony of Rhode Island and Providence
Plantations
14,Vermont,"March 4, 1791[15](admitted)",Vermont Republic[c]
15,Kentucky,"June 1, 1792[16](admitted)",Virginia (nine counties in its District of
Kentucky[d])
16,Tennessee,"June 1, 1796[18](admitted)",Southwest Territory
17,Ohio,"March 1, 1803[19][e](admitted)",Northwest Territory (part)
18,Louisiana,"April 30, 1812[21](admitted)",Territory of Orleans
19,Indiana,"December 11, 1816(admitted)",Indiana Territory
20,Mississippi,"December 10, 1817[22](admitted)",Mississippi Territory
21,Illinois,"December 3, 1818[23](admitted)",Illinois Territory (part)
22,Alabama,"December 14, 1819[24](admitted)",Alabama Territory
23,Maine,"March 15, 1820[25](admitted)",Massachusetts (District of Maine[f])
24,Missouri,"August 10, 1821[26](admitted)",Missouri Territory (part)
25,Arkansas,"June 15, 1836[27](admitted)",Arkansas Territory
26,Michigan,"January 26, 1837[28](admitted)",Michigan Territory
27,Florida,"March 3, 1845(admitted)",Florida Territory
28,Texas,"December 29, 1845(admitted)",Republic of Texas
29,Iowa,"December 28, 1846(admitted)",Iowa Territory (part)
30,Wisconsin,"May 29, 1848[29](admitted)",Wisconsin Territory (part)
31,California,"September 9, 1850[30](admitted)",unorganized territory (part)
32,Minnesota,"May 11, 1858[31](admitted)",Minnesota Territory (part)
33,Oregon,"February 14, 1859(admitted)",Oregon Territory (part)
34,Kansas,"January 29, 1861[32](admitted)",Kansas Territory (part)
35,West Virginia,"June 20, 1863[33](admitted)",Virginia (50 Trans-Allegheny region
counties[g])
36,Nevada,"October 31, 1864(admitted)",Nevada Territory
37,Nebraska,"March 1, 1867(admitted)",Nebraska Territory
38,Colorado,"August 1, 1876[36](admitted)",Colorado Territory
39[h],North Dakota,"November 2, 1889[38][i](admitted)",Dakota Territory (part)
40,South Dakota,"November 2, 1889[38][i](admitted)",Dakota Territory (part)

```

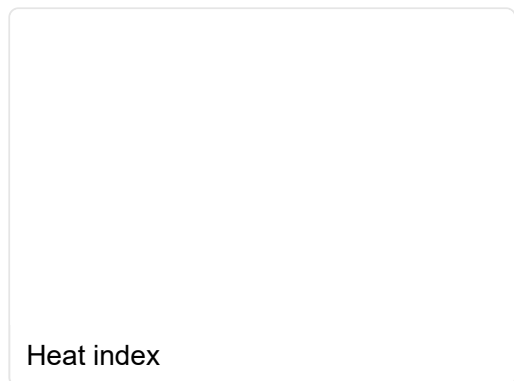
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?

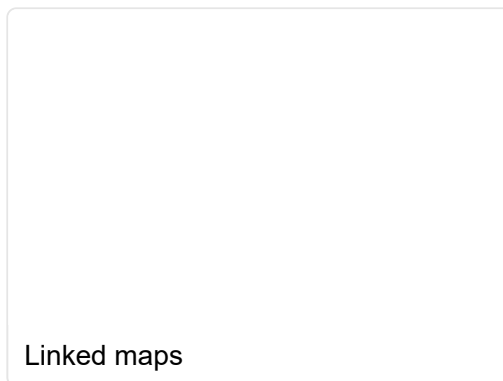
```
42,Washington,"November 11, 1889[40](admitted)",Washington Territory
43,Idaho,"July 3, 1890(admitted)",Idaho Territory
44,Wyoming,"July 10, 1890(admitted)",Wyoming Territory
45,Utah,"January 4, 1896[41](admitted)",Utah Territory
46,Oklahoma,"November 16, 1907[42](admitted)",Oklahoma Territory and Indian Territory
47,New Mexico,"January 6, 1912(admitted)",New Mexico Territory
48,Arizona,"February 14, 1912(admitted)",Arizona Territory
49,Alaska,"January 3, 1959(admitted)",Territory of Alaska
50,Hawaii,"August 21, 1959(admitted)",Territory of Hawaii
`, d => {
  return {
    year: +d.date.split(',')[1].slice(1, 5)
  }
}).map(d => d.year)
```

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