Observable

Sahil Chinoy • Nov 12, 2018
gfx

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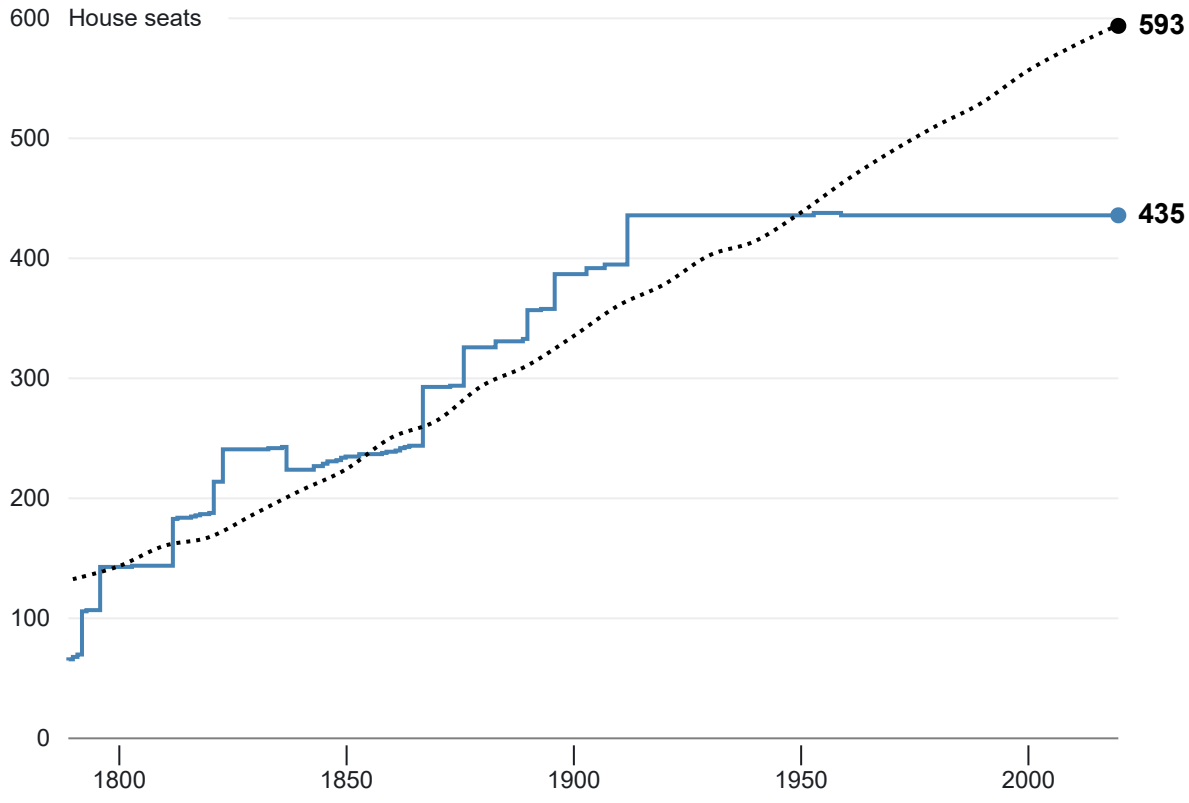
The Cube Root Law

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.



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

```
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: 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'));
```

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```
  .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');
```

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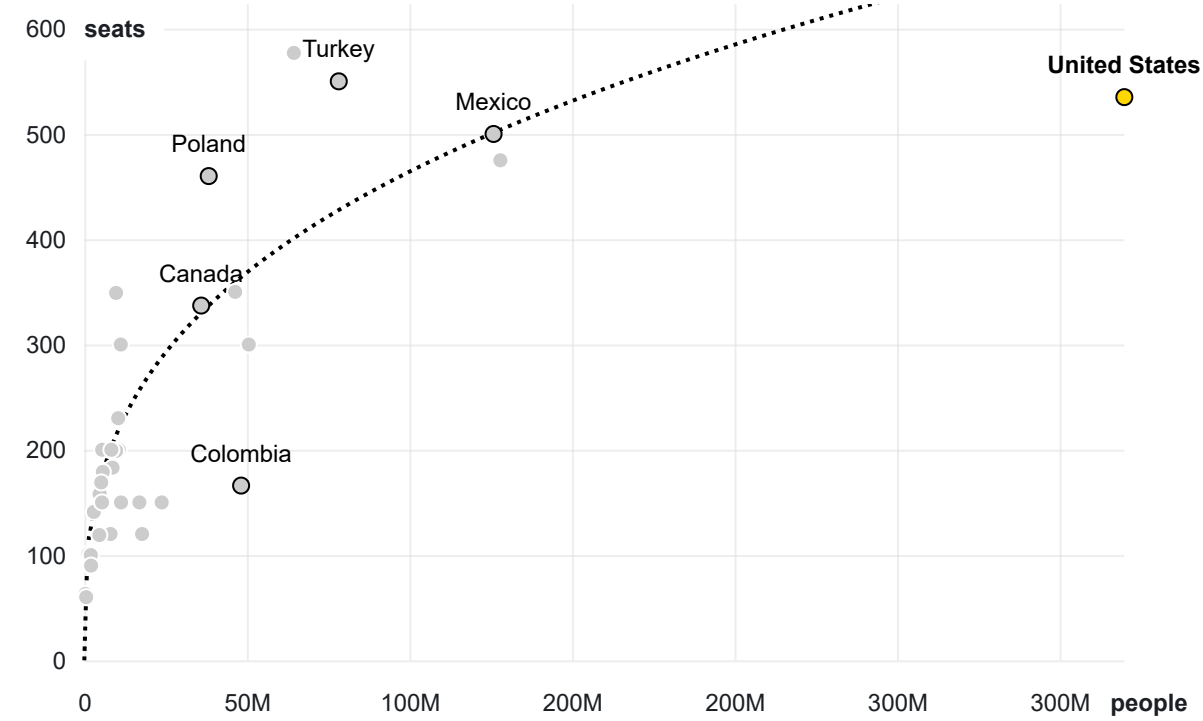
```
  .datum(houseSize[houseSize.length - 1])
  .attr('transform', d => `translate(${x(d.year)}, ${y(d.reps)})`)

  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')
```

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```
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;
}
```

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```
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)
    }
  })
```

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```
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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