Capital and Labor Income Pareto Exponents in the United States, 1916–2019

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Pareto tail

- Random variable $X > 0$ has Pareto upper tail if $\mathrm{P}(X > x) \sim x^{-\alpha}$ for large x, where α: Pareto exponent
- Discovered by Pareto (1896) for income, but holds for other variables:
    - city size (Gabaix, 1999), $\alpha \sim 1$,
    - firm size (Axtell, 2001), $\alpha \sim 1$,
    - COVID cases (Beare and Toda, 2020), $\alpha \sim 1$ ▸ Picture
    - household wealth (Klass et al., 2006; Vermeulen, 2018), $\alpha \sim 1.5$
    - household consumption (Toda and Walsh, 2015), $\alpha \sim 4$,
    - total income (Feenberg and Poterba, 1993; Atkinson and Piketty, 2010), $\alpha \sim 1.5$–3,
    - capital income (de Vries and Toda, 2021), $\alpha \sim 1.5$, etc.

Importance of income and wealth Pareto exponent

- Convenient descriptive statistic for top tail inequality
  (small $\alpha \implies$ high inequality)

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- Theory of optimal taxation (Saez, 2001): optimal top tax rate is $\tau = \frac{1-g}{1-g+\alpha e}$, where
  - $g \in [0, 1]$: marginal utility weight on top earners,
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  - $g \in [0,1]$: marginal utility weight on top earners,
  - e: elasticity of top income w.r.t. tax rate
- Calibration of macroeconomic models
  - average wealth of agents above some threshold is $\frac{\alpha}{\alpha-1}$ times threshold
  - hence wealthy agents have substantial impact on aggregate quantities
  - (see Beare and Toda (2022) for determining α in economic models and Gouin-Bonenfant and Toda (2022) for numerically solving models)

Accurately estimating income α is challenging

- Limitation in data availability
  - micro survey data (CPS, SCF, etc.) have small sample size $n = 10^3 \sim 10^4$
  - survey data suffer from low or inaccurate response
  - micro administrative data hard to access (IRS Public Use File available only for 2009–2014 with $10,000 per year, noise added to data to protect confidentiality)

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  - micro administrative data hard to access (IRS Public Use File available only for 2009–2014 with $10,000 per year, noise added to data to protect confidentiality)
- Limitation in applicability of statistical methods
  - common methods (Hill, 1975; Gabaix and Ibragimov, 2011) assume availability of micro data
  - maximum likelihood can be applied to grouped data if income thresholds observable, but IRS data provides income thresholds only for total income
- Hence existing estimates (i) rarely distinguish capital/labor income, (ii) are likely inaccurate, or (iii) are non-systematic

What we do

- Estimate capital and labor income Pareto exponents in U.S., 1916–2019, using best data and best estimation method
  - distinguishing capital/labor matters because taxed differently
- We use tabulated summaries from IRS *Statistics of Income*
  - administrative data from tax returns (likely accurate)
  - publicly available for 1916–2019
  - large sample size: $n = 10^6 \sim 10^8$
- We apply minimum distance method of Toda and Wang (2021) based on extreme value theory
  - can be applied to grouped data
  - no need to observe income thresholds
  - suffices to observe group averages

What we find

- Based on α, sample period can be divided into three sub periods, pre-1940, 1940–1985, and post-1985
- Post-1985, capital $\alpha \approx 1.2$, labor $\alpha \approx 2.0$
- α lower than existing estimates, hence higher top tail inequality (likely due to underreporting in survey)
- No systematic trend post-1985, so rise in income inequality measured by top income shares (Piketty and Saez, 2003) is inequality between rich and poor, not among rich

General framework

- Income $\{Y_i\}_{i=1}^n$, unobserved by researcher
- Top order statistics $Y_{(1)} \geq Y_{(2)} \geq \cdots \geq Y_{(n)}$
- Partial sums of order statistics $S_m := \sum_{i=1}^m Y_{(i)}$
- Observables are $\{n_k, S_{n_k}\}_{k=1}^K$, where K is number of income groups and $n_1 < n_2 < \cdots < n_K \leq n$

Example: U.S. 2019 tax returns data

Income group		Adjusted gross income (AGI)		Salaries and wages	
k	AGI threshold	# returns	Total income	# returns	Total income
18	$1	9,866,880	24,439,988	6,672,531	23,927,191
17	$5,000	9,925,940	74,584,857	7,622,306	58,927,624
16	$10,000	11,087,737	138,230,399	8,277,447	100,631,554
15	$15,000	10,039,446	175,255,963	7,931,946	134,897,400
14	$20,000	9,493,968	213,660,160	7,855,283	173,142,941
13	$25,000	9,289,939	254,877,708	7,943,835	212,428,275
12	$30,000	16,090,602	560,073,192	14,045,867	471,544,226
11	$40,000	12,503,041	560,258,808	10,931,707	465,547,848
10	$50,000	22,238,948	1,366,892,948	18,976,338	1,071,062,478
9	$75,000	14,118,568	1,222,947,425	12,033,727	921,390,540
8	$100,000	21,997,582	3,004,363,636	19,028,674	2,209,484,837
7	$200,000	7,297,883	2,090,808,696	6,414,121	1,429,162,189
6	$500,000	1,162,371	781,920,814	1,010,488	449,489,139
5	$1,000,000	254,197	305,561,848	214,955	141,101,999
4	$1,500,000	103,075	176,961,208	85,285	72,754,006
3	$2,000,000	143,514	425,088,995	117,168	145,270,762
2	$5,000,000	34,738	237,781,553	28,162	66,367,353
1	$10,000,000	20,876	590,230,011	16,866	102,518,828
All returns, total		157,796,807	11,966,873,976	129,775,754	8,273,071,046

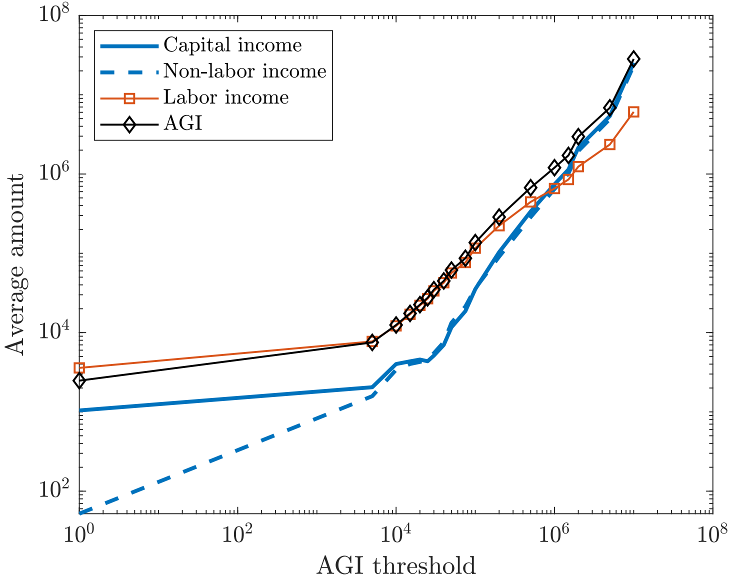
Details on data

- Primary data is *Statistics of Income (SOI) Individual Tax Returns Publication 1304* from IRS
  - Excel spreadsheets available since 1993 (Table 1.4 at https://www.irs.gov/statistics/soi-tax-stats-individual-income-tax-returns-complete-report-publication-1304-basic-tables-
    ▸ SOI 2019
  - Before 1993, only PDFs of scanned copies of SOI are available (https://www.irs.gov/statistics/soi-tax-stats-archive) ▸ SOI 1919
- Before 1993, manually input adjusted gross income (AGI), AGI thresholds, salaries and wages, and number of returns into spreadsheets
- Human errors inevitable (for each year, we typed 10-digit numbers 100 times); checked accuracy by comparing column sums of spreadsheet to sums reported in SOI tables

Definitions of incomes

- We define
  - Total income := "adjusted gross income (AGI)"
  - Labor income := "salaries and wages"
  - Capital income := non-labor income = AGI − labor income
- This definition of capital income is broad and includes clearly non-capital income such as ``state income tax refunds'', ``alimony received'', ``unemployment compensation''
- Hence also consider adding up capital income components such as ``taxable interest'', ``tax-exempt interest'', ``ordinary dividends'', ``qualified dividends'', ``business or profession'', ``capital gain distributions reported on Form 1040'', ``sales of capital assets reported on Form 1040, Schedule D'', ``sales of property other than capital assets'', ``taxable Individual Retirement Arrangement (IRA) distributions'', ``pensions and annuities'', ``total rent and royalty'', ``partnership and S corporation'', ``estate and trust''

Capital income ≈ non-labor income for AGI > 25k

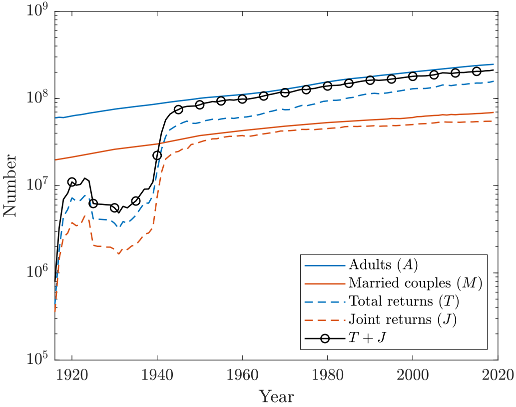


Sample size

- Our unit of analysis is tax unit
  - individuals or married couples filing jointly, with dependents if any
- We only observe tax filers
  - non-filer could have income below filing requirement or work in informal sectors using cash and evade taxes
- Sample size (number of potential tax units) necessary for estimation (definition of top fractiles)
- To estimate sample size, we collect data on
  - number of total returns (T),
  - number of joint returns (J),
  - number of adults (A),
  - number of married couples (M)

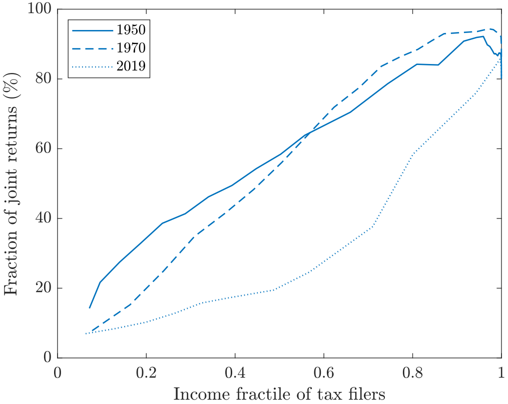
Number of adults and tax returns

- If {Adults} = {Tax filers}, then $A = T + J$
  - Post-1950, $(T+J)/A \approx 0.9$, so missing about 10% of adults
  - Pre-1945, missing 90-99% of adults due to high exemptions (Tax Reform Act of 1942)



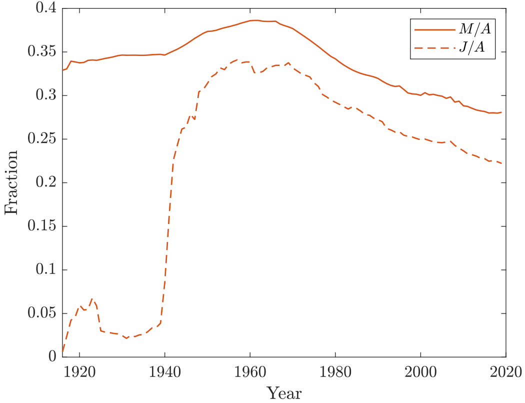
Income fractiles and joint returns

- Low (high) income earners tend to file separately (jointly)
- Hence can estimate sample size as $n = A - J$
- Still need to estimate J for pre-1950



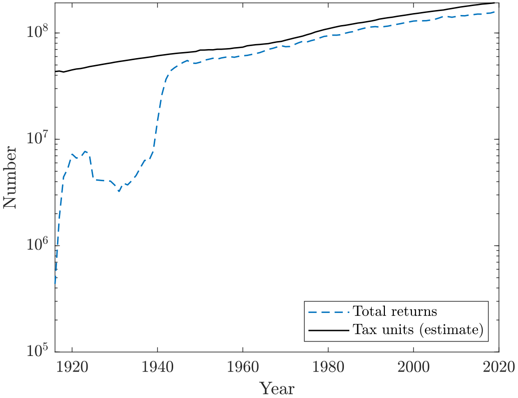
Married couples and joint returns

- Post-1950, married/adults (M/A) and joint/adults (J/A) have common trends
- Regress $\log(J/A)$ on $\log(M/A)$ ($R^2 = 0.989$) post-1950 and use OLS estimates to construct $\widehat{J}$ pre-1950



Potential tax units

- Use $n = A - J(\widehat{J})$ (upper bound)
- Using $n = A - M$ (lower bound, assuming all married couples file jointly, as Piketty and Saez (2003) do) has no material impact ▸ robustness



Estimation

- We now have data on $\{(n_k, S_{n_k})\}_{k=1}^K$ and n, where $n_1 < n_2 < \cdots < n_K \leq n$
- We apply the minimum distance method of Toda and Wang (2021) (TW) to estimate income Pareto exponents
- Here are basic idea of TW method
  - Letting $J : [0, 1] \to \mathbb{R}$ a bounded and almost everywhere continuous function, the asymptotic behavior of weighted sums of order statistics

$$\frac{1}{n}\sum_{i=1}^{n} J\left(\frac{i}{n+1}\right) Y_{(n-i+1)}$$

    is known (Stigler, 1974)
  - Let $p_k = n_k/n$ be top fractile

Estimation

- Basic idea (continued)
  - Letting $J(x) = \mathbb{1}(1 - p_{n_{k+1}} < x \leq 1 - p_{n_k})$, we have

$$\frac{1}{n}\sum_{i=1}^{n} J\left(\frac{i}{n+1}\right) Y_{(n-i+1)} = \frac{S_{n_{k+1}} - S_{n_k}}{n}$$

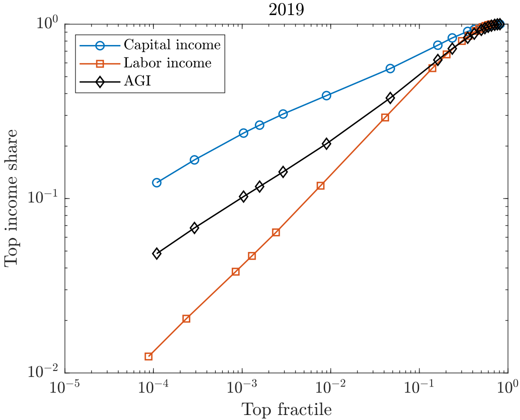
  - Hence if we consider self-normalized quantity

$$s := \left(\frac{S_{n_2} - S_{n_1}}{S_{n_{L+1}} - S_{n_L}}, \dots, \frac{S_{n_L} - S_{n_{L-1}}}{S_{n_{L+1}} - S_{n_L}}\right),$$

    asymptotic behavior depends only on Pareto exponent α if $\{Y_i\}$ have Pareto upper tail and $n_{L+1} \ll n$
  - Can estimate α by minimizing quadratic distance of s from theoretical value implied by Pareto distribution

Is Pareto tail reasonable?

- If income has Pareto upper tail with exponent α, top p fractile income share is $S(p) \propto p^{1-1/\alpha}$
- Hence top fractiles and shares should be linear in log-log scale

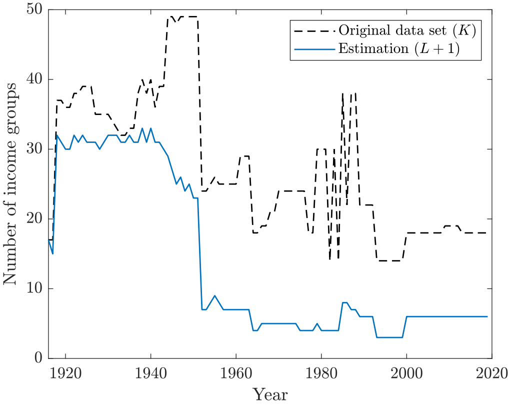


Assumptions

- For estimation, we need partial sums of order statistics
- In IRS data, income groups are defined by order of AGI
- We assume AGI and capital income are ordered in the same way *across* income groups (e.g., tax filers in group k have higher capital income than those in group $k+1$ for $k = 1, \dots, L$)
  - Reasonable for capital income if L not too large because AGI $\approx$ capital income for top earners average income
  - Unreasonable for labor income because labor income $\ll$ AGI for top earners

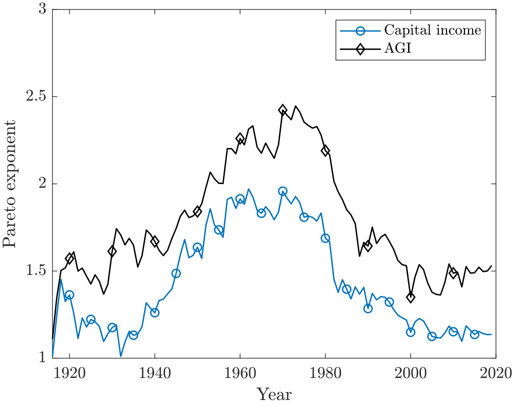
Choice of income groups

- Literature typically uses top 5% observation for estimation
- We choose largest L such that $n_{L+1}/n \leq 0.01$ (top 1%) to be conservative, given large sample size (and need $L+1 \geq 3$)
- Results are robust to different cutoffs ▸ robustness



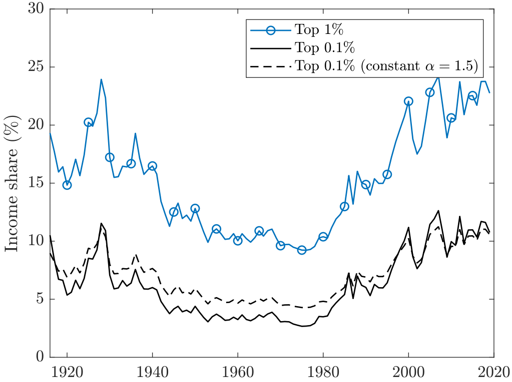
AGI and capital income Pareto exponents

- Capital $\alpha \approx 1.2$ pre-1940 and post-1985, inverse U-shape in 1940–1985, AGI α similar pattern
- Standard error omitted because order of magnitude $(10^8 \times 0.01)^{-1/2} = 10^{-3}$



No rise in top tail inequality post-1985

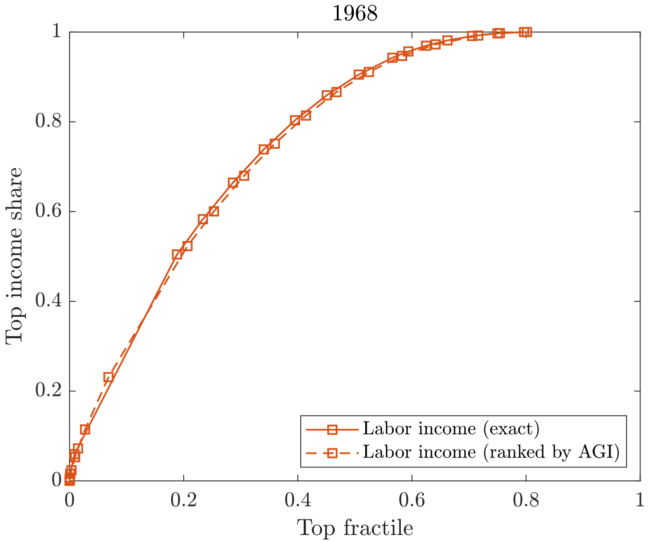
- Top income shares have risen post-1985
- If income Pareto, then $S(p) = (p/q)^{1-1/\alpha} S(q)$
- $S(p)$ constructed from $(p, q) = (0.001, 0.01)$ and $\alpha = 1.5$ is similar to actual $S(p)$ post-1985, confirming stable top tail inequality



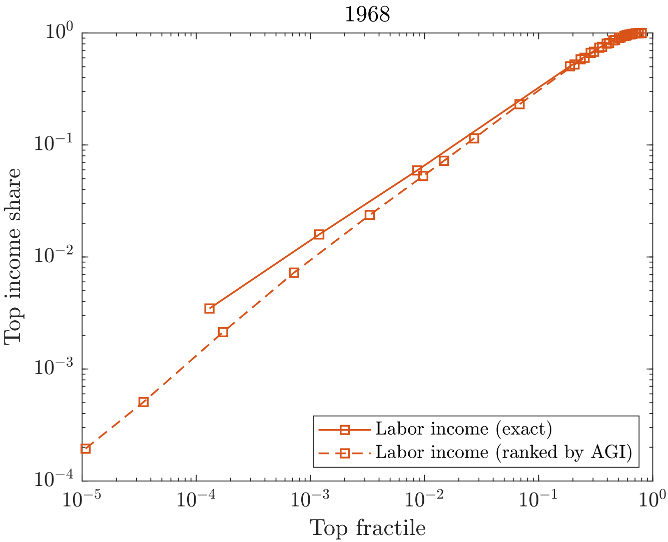
Labor income Pareto exponents

- Several issues when estimating labor income exponents
  - Not necessarily reasonable to assume same ordering of AGI and labor income across income groups
  - Size distribution of labor income available only for subset of 1927–1978
- For a particular year (1968) the joint distribution of AGI and labor income is available, compare top labor income shares

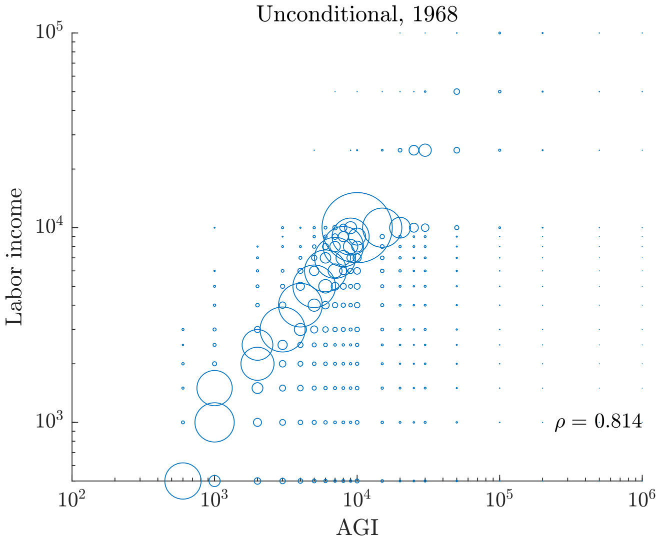
Top labor income shares, 1968



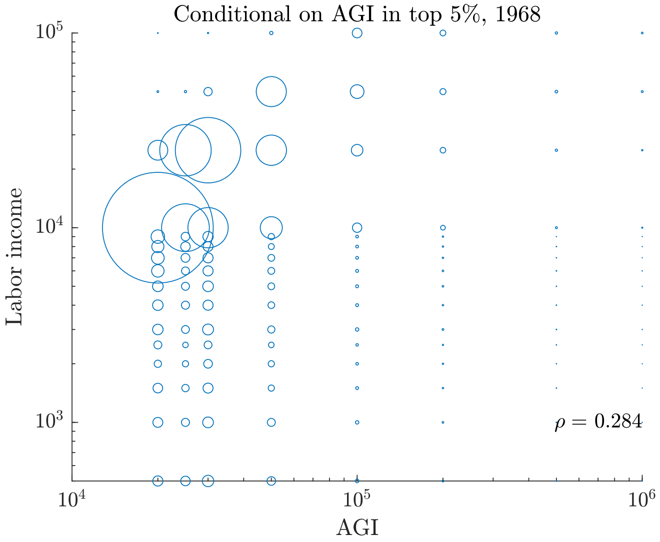
Top labor income shares, 1968



Joint distribution of AGI and labor income

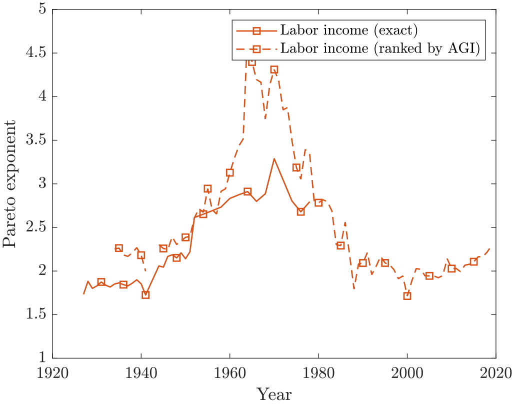


Joint distribution of AGI and labor income



Labor income Pareto exponents

- These figures suggest that AGI and labor income are highly correlated, but excluding top incomes
- We simply report two numbers using labor income ranked exactly (1927–1978) and ranked by AGI (1934–2019)

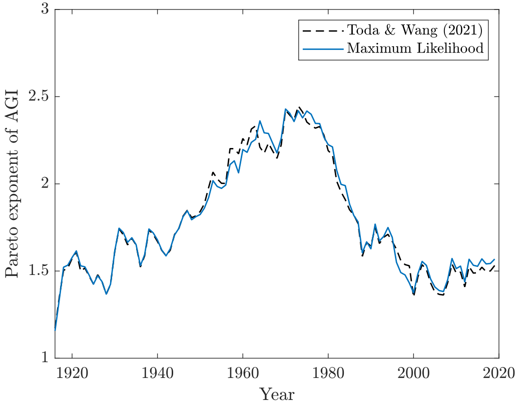


Comparison to existing estimates

- We compare to existing estimates,
  - maximum likelihood (only AGI due to applicability of estimation method),
  - Feenberg and Poterba (1993) (only AGI due to applicability of estimation method),
  - Atkinson and Piketty (2010) (only AGI due to applicability of estimation method),
  - de Vries and Toda (2021) (capital and labor income exponents)

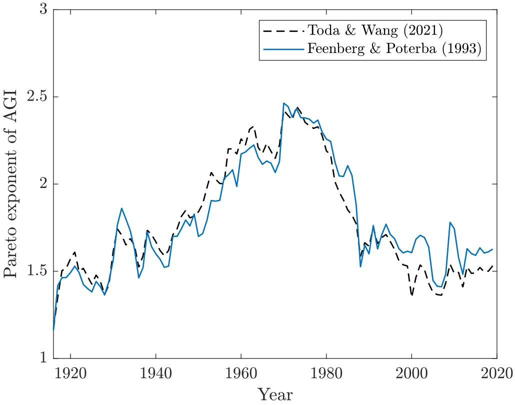
Maximum likelihood

- For AGI, we observe income thresholds $\infty = t_0 > t_1 > \cdots > t_K > 0$
- Can apply ML using conditional tail probability $P(Y \geq y \mid Y \geq t_L) = (y/t_L)^{-\alpha}$



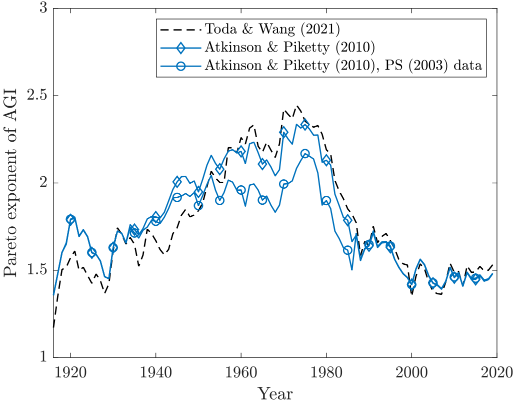
Feenberg and Poterba (1993)

- Feenberg and Poterba (1993) find two income thresholds $y_1 < y_2$ that bracket the top 0.5%
- Estimate $\widehat{\alpha} = \log[(1 - F(y_1))/(1 - F(y_2))]/\log(y_2/y_1)$ using Pareto CDF



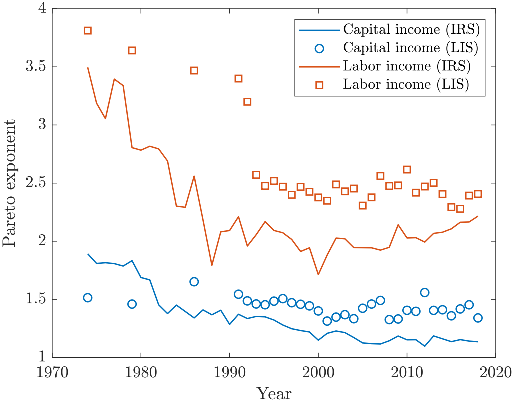
Atkinson and Piketty (2010)

- If income Pareto, top p fractile income share is $S(p) \propto p^{1-1/\alpha}$
- Estimate $\widehat{\alpha} = \left(1 - \frac{\log[S(q)/S(p)]}{\log(q/p)}\right)^{-1}$ using top income shares of Piketty and Saez (2003) difference?



de Vries and Toda (2021)

- de Vries and Toda (2021) apply Hill (1975) estimator to micro data (*Luxembourg Income Study*, which is CPS for U.S.)
- Estimates from survey data biased upwards, suggesting low response/underreporting by rich



Concluding remarks

- First systematic estimates of capital and labor income Pareto exponents in U.S., 1916–2019
- Post-1985, exponents stable at capital $\alpha \approx 1.2$, labor $\alpha \approx 2.0$
- α lower than existing estimates (higher top tail inequality)
- No systematic trend post-1985, so rise in income inequality is inequality between rich and poor, not among rich

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Statistics of Income 2019

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Table 1.4. All Returns: Sources of Income, Adjustments, and Tax Items, by Size of Adjusted Gross Income, Tax Year 2019 (Filing Year 2020)

(All figures are estimates based on samples—money amounts are in thousands of dollars)

Size of adjusted gross income	Total income		Salaries and wages	
	Number of returns	Amount	Number of returns	Amount
	(3)	(4)	(5)	(6)
All returns, total	**157,197,473**	**12,111,799,488**	**129,775,754**	**8,273,071,046**
No adjusted gross income	1,528,166	-234,790,580	569,047	23,421,857
$1 under $5,000	9,866,880	25,527,613	6,672,531	23,927,191
$5,000 under $10,000	9,925,940	76,354,338	7,622,306	58,927,624
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$500,000 under $1,000,000	1,162,371	795,166,354	1,010,488	449,489,139
$1,000,000 under $1,500,000	254,197	310,038,042	214,955	141,101,999
$1,500,000 under $2,000,000	103,075	179,090,416	85,285	72,754,006

Statistics of Income 1919

https://www.irs.gov/pub/irs-soi/19soirepar.pdf

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TABLE 2.—PERSONAL RETURNS—DISTRIBUTION BY INCOME CLASSES, FOR THE UNITED STATES; *showing for each class of income, the number of returns, net income, personal exemption, dividends, tax paid, and percentages.*

[Income returned for the calendar year ended Dec. 31, 1919.]

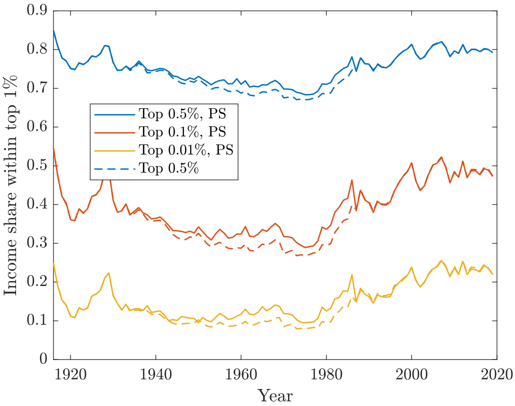
Income class.	Number of returns.	Net income.	Exemptions from normal tax.			Normal tax.	Surtax.	Total tax.	Average amount of tax per individual.	Average rate of tax per cent.
			Personal exemption.	Dividends.	Interest on Government obligations.[1]					
$1,000 to $2,000 [2]	536,046	$829,331,321	$1,097,674,000	$30,009,938						
$1,000 to $2,000	1,388,826	1,999,781,830	1,382,966,700	13,579,107	$66,492	$24,696,200		$24,696,200	$17.78	1.23
$2,000 to $3,000 [2]	529,269	1,207,859,326	1,290,453,500	47,771,042						
$2,000 to $3,000	1,040,472	2,599,427,039	1,869,820,100	35,964,156	80,797	28,257,861		28,257,861	27.16	1.09
$3,000 to $4,000 [2]	27,305	90,743,612	61,975,500	38,730,159	8,239					
$3,000 to $4,000	715,029	2,462,185,894	1,476,226,400	53,715,584	200,533	37,658,780		37,658,780	52.67	1.53
$4,000 to $5,000 [2]	8,959	39,937,529	16,874,100	33,191,526						
$4,000 to $5,000	429,195	1,920,396,995	897,842,600	72,522,462	450,405	38,256,067		38,256,067	89.13	1.99
$5,000 to $6,000	167,005	913,242,237	347,919,700	69,000,834	3,026,550	20,030,959	$806,926	20,837,885	124.77	2.28
$6,000 to $7,000	109,674	704,233,382	225,877,600	71,044,145	3,067,587	17,210,561	2,006,798	19,217,359	175.22	2.73
$7,000 to $8,000	73,719	549,005,475	150,724,400	65,148,884	2,870,049	15,515,438	2,777,662	18,293,100	248.15	3.33
$8,000 to $9,000	50,486	427,391,591	102,799,600	60,061,704	2,446,223	13,688,701	3,171,449	16,860,150	333.96	3.94
$9,000 to $10,000	37,967	360,264,568	76,802,600	56,969,770	2,088,305	12,747,806	3,581,610	16,329,416	430.09	4.53
$10,000 to $11,000	28,499	298,741,396	57,115,600	51,548,052	1,895,801	11,115,245	3,693,637	14,808,882	519.63	4.96
$11,000 to $12,000	22,841	262,547,502	45,680,400	48,218,135	1,769,071	10,344,570	3,857,490	14,202,060	621.78	5.41
$12,000 to $13,000	18,423	230,074,304	36,701,800	44,080,679	1,211,800	9,512,024	3,940,208	13,452,232	730.19	5.85
$13,000 to $14,000	15,248	205,859,632	30,323,200	40,957,190	1,200,502	8,698,603	4,017,757	12,716,360	833.97	6.18
$14,000 to $15,000	12,841	186,215,957	25,310,600	39,885,022	1,160,745	7,984,373	4,100,174	12,084,547	941.09	6.48
$15,000 to $20,000	42,028	724,378,165	82,021,000	169,956,875	4,896,657	32,286,924	20,918,502	53,205,426	1,265.95	7.34
$20,000 to $25,000	22,605	504,458,801	43,590,200	132,167,485	3,640,965	23,483,480	20,879,536	44,363,016	1,962.53	8.79
$25,000 to $30,000	13,769	376,457,979	26,438,800	109,083,845	2,723,665	17,675,537	20,271,767	37,947,304	2,756.00	10.08
$30,000 to $40,000	15,410	530,754,145	29,009,400	168,692,831	4,137,076	25,093,240	38,081,884	63,175,124	4,099.62	11.90
$40,000 to $50,000	8,298	370,152,511	15,626,600	121,825,056	2,542,459	17,948,138	35,875,777	53,823,915	6,486.37	14.54
$50,000 to $60,000	5,213	284,768,434	9,699,400	99,625,332	1,968,291	13,764,825	34,864,546	48,629,371	9,328.48	17.08
$60,000 to $70,000	3,196	206,515,321	5,892,000	74,815,645	1,762,469	9,818,475	30,326,310	40,144,785	12,560.95	19.44
$70,000 to $80,000	2,237	167,052,648	4,171,400	64,433,929	1,265,842	7,864,732	28,644,868	36,509,600	16,320.79	21.86
$80,000 to $90,000	1,561	132,629,947	2,847,800	49,816,222	1,125,061	6,439,707	26,120,745	32,560,452	20,858.71	24.55
$90,000 to $100,000	1,113	105,530,859	2,012,200	39,384,249	966,971	5,098,466	23,414,934	28,513,400	25,618.51	27.02
$100,000 to $150,000	2,983	358,392,923	5,323,200	146,150,758	3,757,325	17,401,853	101,303,450	118,705,303	39,793.93	33.12
$150,000 to $200,000	1,092	187,816,010	1,940,200	82,854,462	2,264,258	8,891,502	68,081,248	76,972,750	70,487.87	40.98
$200,000 to $250,000	522	115,428,091	983,600	16,356,471	1,833,054	5,682,396	47,071,736	52,754,132	101,061.56	45.71
$250,000 to $300,000	250	67,904,435	440,400	29,351,109	854,406	3,253,588	30,114,879	33,368,467	133,473.87	49.14
$300,000 to $400,000	285	96,614,153	494,800	46,486,908	1,098,507	4,615,053	46,209,076	50,824,129	178,330.28	52.61

[1] Interest on Government obligations not wholly exempt from tax.

[2] Nontaxable. Personal exemption and dividends exceed net income.

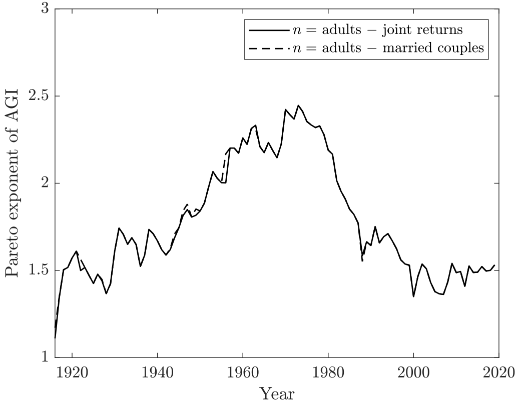
Top relative income shares

- If income Pareto, top p fractile income share is $S(p) \propto p^{1-1/\alpha}$
- Hence top relative income share $S(p)/S(q) = (p/q)^{1-1/\alpha}$ depends only on α and top relative fractile p/q



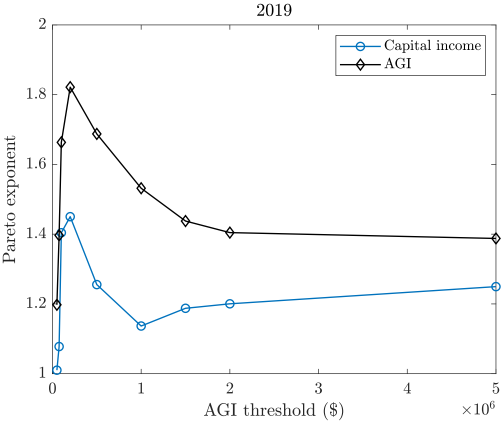
Robustness to sample size

- We use $n = A - J$ for sample size
- Using $n = A - M$ has no material impact



Robustness to choice of income groups

- We use top 1% for estimation



Size distribution of COVID cases across U.S. counties

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