When Aiyagari meets Piketty: Growth, Inequality and Capital Shares*

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Piketty (2014) and related literature I

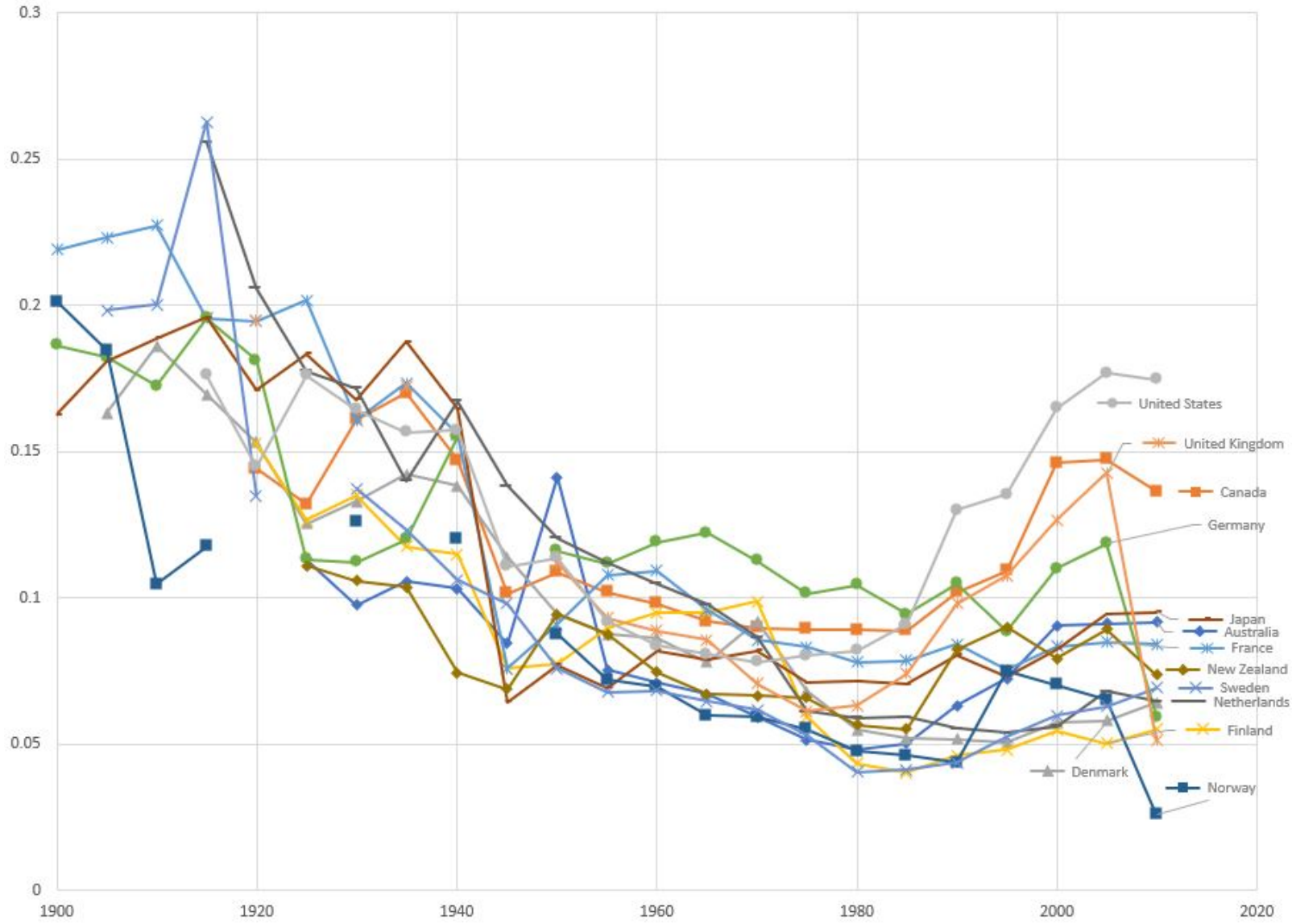

Figure: Top 1 % share of total national income

Piketty (2014) and related literature II

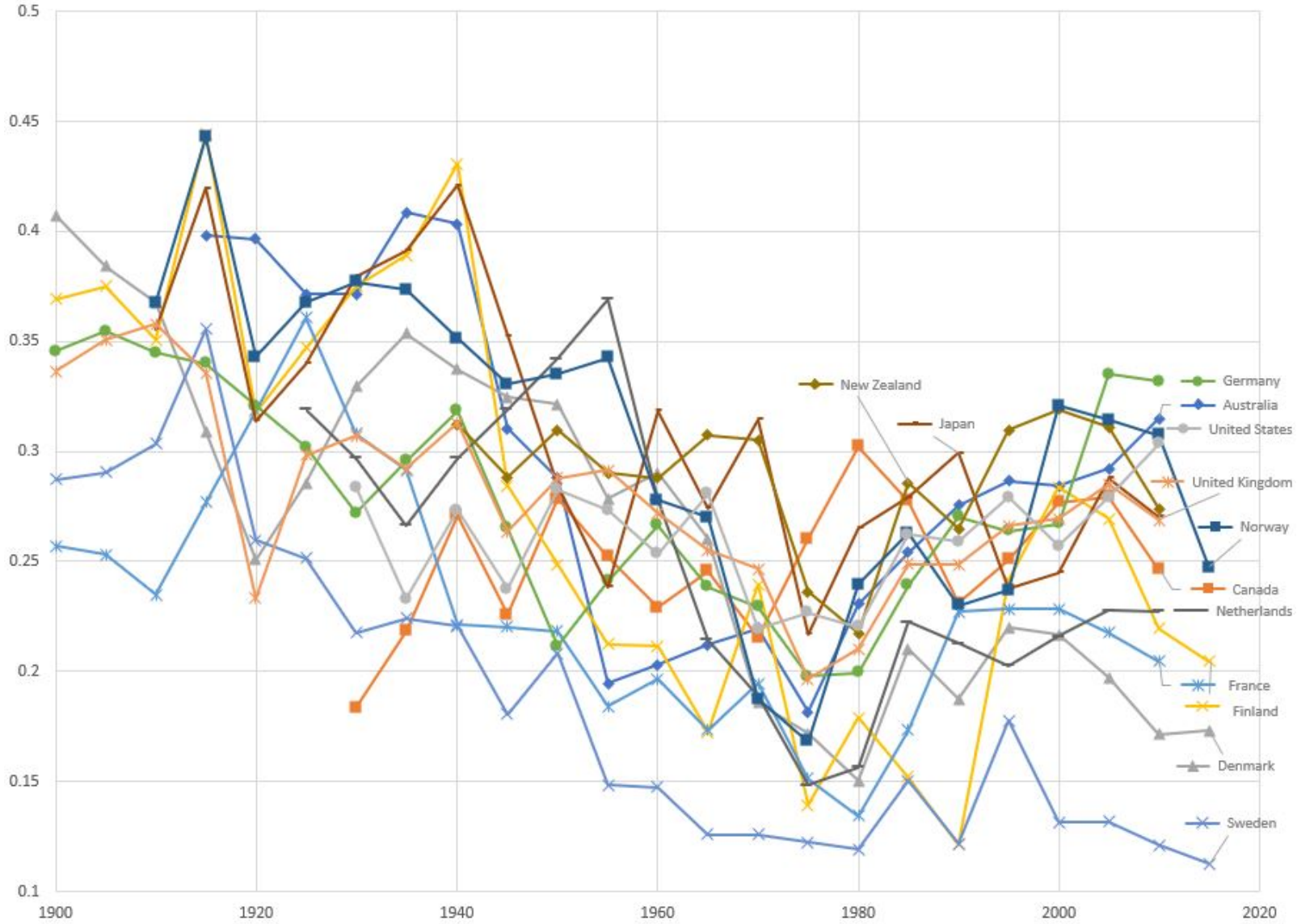

Figure: Capital share of total national income

Functional income distribution and income inequality

A well-recognized link:

- Common wisdom and e.g. Piketty (2014): capital income is more unevenly distributed than labor income, and thus, rising capital shares are positively associated with income inequality
- Theoretical work: Atkinson (2009) and Milanovic (2016)
- Empirical work: Daudey and García-Peñalosa (2007), Checchi and García-Peñalosa (2010), Bengtsson and Waldenström (2018) and Civardi and Lenti (2018)

Inequality and economic growth: large previous literature

- Theoretical studies have suggested numerous plausible mechanisms
- Empirical studies have aimed at
  i) estimating the association between inequality and growth, and
  ii) testing for the relevance of the suggested mechanisms
- Not covered in the literature: functional income distribution as a potential determinant of the inequality-growth relationship
  $\longrightarrow$ this is what we do

Our contribution

Show that the **inequality-growth relationship is conditional on the division of income between capital and labor**

- Theoretically, we adopt the seminal model by Aiyagari (1994)
  - Focus on the accumulation of capital
  - Illustrate the key features in a simple capital market equilibrium
- Empirically, we adopt a standard panel growth regression and rely on data compiled by Bengtsson and Waldenström (2018)
  - 13 developed countries, five-year non-overlapping windows

Main result:

Capital share	*Inequality* $\longrightarrow$ *growth*
Low	Positive
High	Negative

Overview

1. Inequality-growth literature
2. The model
3. Data
4. Empirical approach
5. Empirical results
6. Conclusion

Does inequality matter for growth?*

1. Theoretical predictions
   - Traditional arguments state that inequality enhances growth through incentives and higher savings rate of the rich
   - A surge of formal counterarguments during the past 30 years (human capital, leaky bucket, instability, fertility,...)
   - Often, credit constraints play a key role
2. Empirical evidence
   - In brief, inconclusive
   - The typical caveats related to cross-country panel studies apply (associations rather than causal results, heterogeneity across countries, policy relevance,...)

*For interested, some focal studies listed at the end of the presentation

A non-standard workshop to study the growth-consequences of inequality: Aiyagari (1994)

The original paper

- Standard growth model that includes **precautionary saving motives** and **liquidity constraints**

Our paper

- Specification and parameterization **follow Aiyagari (1994)**
- Normalize the labor force to unity and **study capital accumulation**
- **We focus on**
  - inequality modeled through income uncertainty
  - credit constraint
  - capital share, α

Levers we pull: income uncertainty, credit constraint and α

All household are ex-ante symmetric and each of them solves the following recursive problem

$$V(a_t, \ell_t) = \max_{c_t, a_{t+1}} \left\{ u(c_t) + \beta \int_{\ell_{min}}^{\ell_{max}} [V(a_{t+1}, \ell_{t+1})] \, dF(\ell_{t+1}) \right\} \tag{1}$$

subject to

$$a_{t+1} + c_t = (1 + r_t)a_t + w_t \ell_t \tag{2}$$

$$a_t \geq \underline{a} \qquad \text{almost surely} \tag{3}$$

$$c_t \geq 0 \tag{4}$$

$$c_0, k_0 \text{ given}, \tag{5}$$

For labor endowment, we discretize the following AR(1) process:

$$\log(\ell_t) = \rho \log(\ell_{t-1}) + \sigma \sqrt{(1 - \rho^2)} \varepsilon_t, \tag{6}$$

Standard firm-side with a Cobb-Douglas production function.
We analyze $\alpha \in \{0.1, 0.2, 0.3, 0.4, 0.5\}$ while Aiyagari (1994) used $\alpha = 0.36$.

Income uncertainty and income inequality

Change in σ changes the labor endowment states (s=7 as in Aiyagari (1994))

- See resource constraint: income is given by $w_t \ell_t$
- Gini increases from 0.1588 to 0.1642 (small Gini a typical feature)

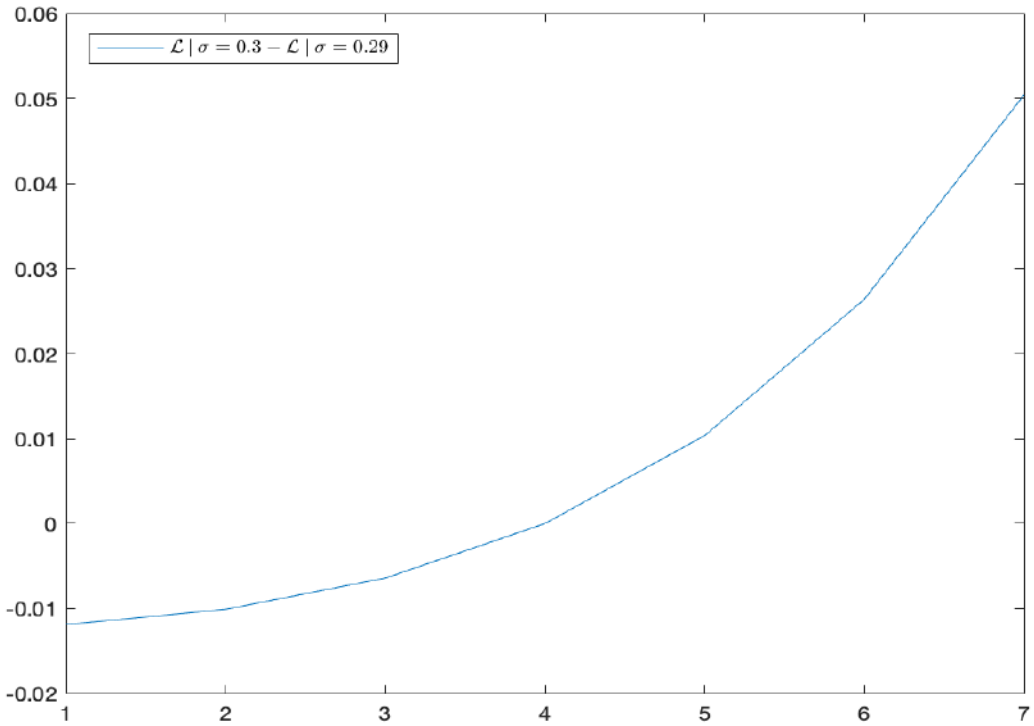

Figure: Change in labor endowment states between $\sigma = 0.29$ and $\sigma = 0.30$

Capital market equilibria (stem from Aiyagari (1994)) I

A simple framework to illustrate what is going on in the model

- Demand of capital depends on α (not on inequality)
- Supply of capital when credit constraint is low:
  1. Due to precautionary (net) savings, an increase in income uncertainty increases the capital supply
  2. Due to consumption smoothing, an increase in income (economy grows!) decreases the capital supply
  - For low r, 1 dominates: due to low yield and uncertainty, households prepare, which translates into higher capital supply (elasticity $\downarrow$)
  - For high r, 2 dominates: high yield and growing economy offset the precautionary motives, which translates into lower capital supply

$\longrightarrow$ Supply shifts and pivots after an inequality shock

Capital market equilibria (stem from Aiyagari (1994)) II

"shock": an increase in inequality, and $y = k^{\alpha}$

- Inequality is *positively* associated with growth when α is *small*
- Inequality is *negatively* associated with growth when α is *large*

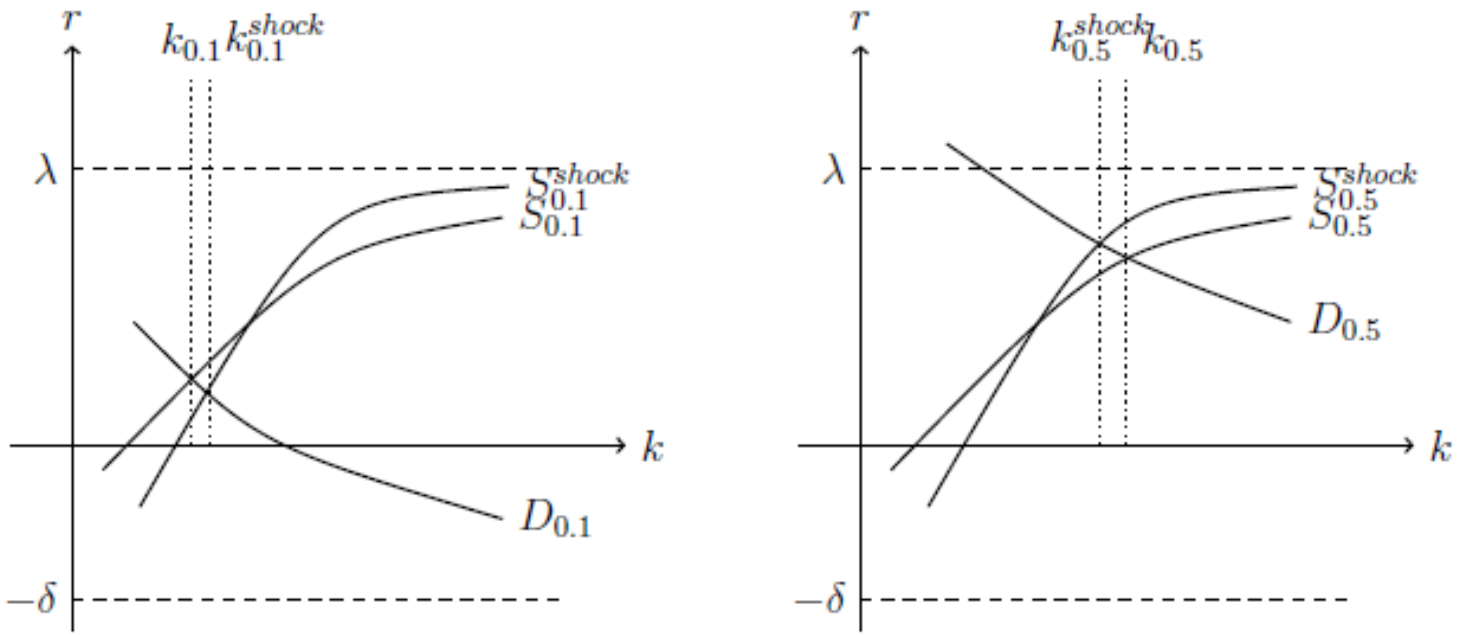

Figure: Equilibria in Capital Market with $\alpha \in \{0.1, 0.5\}$

Capital market equilibria (stem from Aiyagari (1994)) III

What if the credit constraint is high? Recall:

1. Due to precautionary (net) savings, an increase in income uncertainty increases the capital supply
2. Due to consumption smoothing, an increase in income (economy grows!) decreases the capital supply

Under high credit constraint,

- the households cannot borrow as easily, i.e. consumption smoothing (2) is more difficult and precautionary savings (1) dominate irrespective of α and r
- consequently, income inequality is positively associated with capital accumulation and overall economic activity irrespective of α

How we pull the levers?

No analytical solution, we simulate

- Inequality: from $\sigma = 0.29$ to $\sigma = 0.30$
- Capital share: $\alpha \in \{0.1, 0.2, 0.3, 0.4, 0.5\}$ (sample min and max are 0.12 and 0.44, respectively, while the mean is 0.26)
- A discrete asset grid: $\mathcal{A} = \{A_1, A_2, \ldots, A_n\}$, $A_n = 50$, and changes in the credit constraint are modelled through $A_1 \in \{0, 0.5, 1.0, 1.5, 2.0\}$

The main predictions graphically

For low credit constraint ($A_1 \leq 1$)

- Inequality is *positively* associated with growth when α is *small*
- Inequality is *negatively* associated with growth when α is *large*

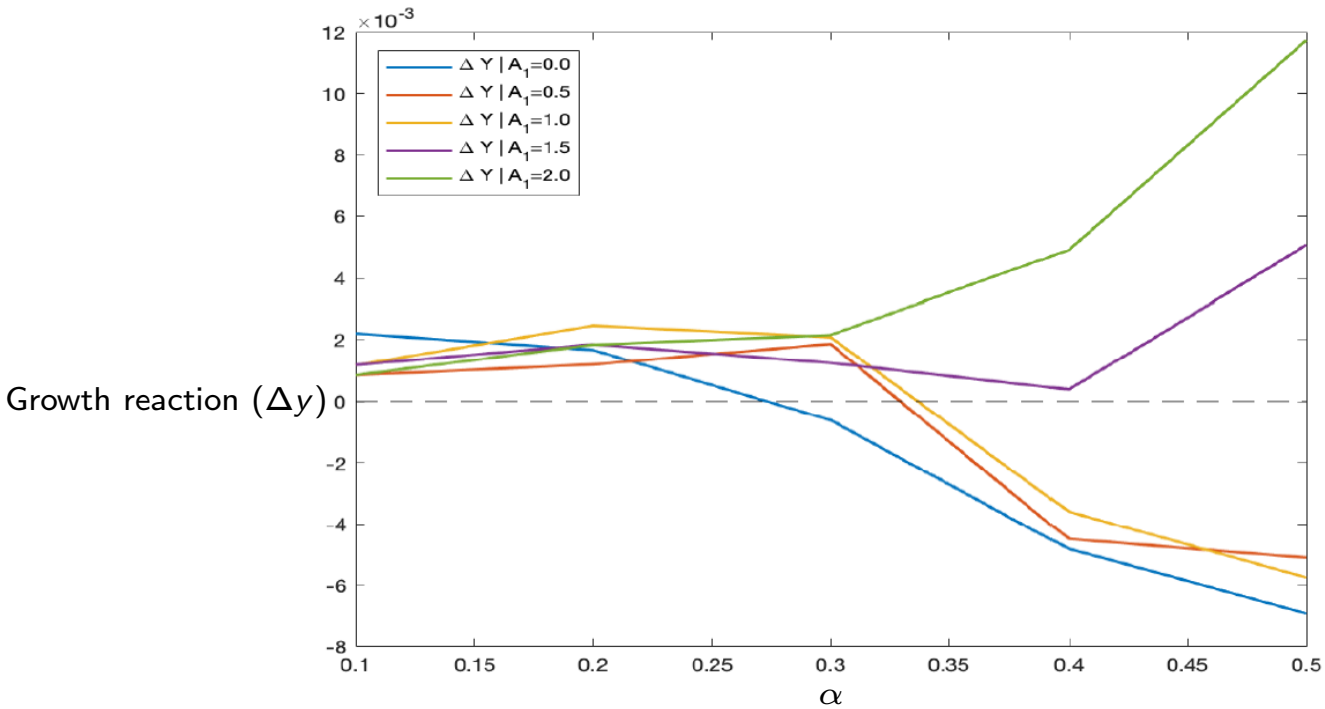

Figure: Simulated reactions to inequality shock

Summing up the theory

Capital accumulation as a sole engine of growth

- We use historical data set $\longrightarrow$ sensible modelling choice
- As opposed to convex savings function argument (Kaldor, 1957; Bourguignon, 1981), inequality does not necessarily promote capital accumulation

Next: how does this look when we turn our focus to historical data?

Sources and coverage

Sources

- Bengtsson and Waldenström (2018): Top 1 % shares and capital shares in a spirit of the World Inequality Database
- Maddison project (Bolt et al., 2018): Per capita GDP
- Rajan and Zingales (2003): Credit constraint / financial development

Coverage: 13 developed countries over the 20th cent. and early 21st cent.

- 230 total observations (five-year growth windows)
- On average, 18 five-year windows per country (min: 13, max: 22)

Detailed coverage

For a given year t, the growth of per capita GDP is the annualized growth rate from t to $t+4$. The explanatory variables are averages over $t-5$ and $t-1$.

Year	AUS	CAN	DNK	FIN	FRA	DEU	JPN	NLD	NZL	NOR	SWE	GBR	USA
1900						✓							
1905					✓	✓							
1910			✓		✓	✓					✓		
1915			✓		✓	✓	✓			✓	✓		
1920			✓		✓	✓	✓			✓	✓		
1925			✓	✓	✓	✓	✓				✓	✓	
1930	✓		✓	✓	✓	✓	✓	✓					
1935	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓
1940	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓
1945	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
1950	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓
1955	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1960	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1965	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1970	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1975	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1980	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1985	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1990	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1995	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2005	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2010		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓

Top 1 % shares and capital shares

We use these data over some other alternatives to analyze long-run evolutions and to connect with Piketty (2014) and related literature

- Top 1 % share of pre-tax national income
  - Outperforms e.g. the Gini in historical coverage
  - The top income shares highly correlated w/ e.g. the Gini (Leigh, 2007)
  - The data exclude some forms of capital income (work on distributional national accounts in progress, someone should do this for Finland...)
- Capital share of pre-tax national income
  - Bengtsson and Waldenström (2018) follow Piketty and Zucman (2014)
  - Capital income (interest, profits, dividends and realized capital gains) as a share of national income
  - The good old Cobb-Douglas α

Reduced-form panel growth regression I

Estimating the association between expenditure-side real per capita GDP (Y), income inequality ($Top1$) and functional income distribution (α):

Growth window:	Explanatory variables:
From t to $t+4$	From $t-5$ to $t-1$

$$\begin{aligned}\frac{1}{4}(lnY_{i,t+4} - lnY_{i,t}) = \beta_1(\frac{1}{5}\sum_{j=0}^{4} lnY_{i,t-5+j}) + \beta_2(\frac{1}{5}\sum_{j=0}^{4} Top1_{i,t-5+j}) \\ + \beta_3(\frac{1}{5}\sum_{j=0}^{4} \alpha_{i,t-5+j}) + \beta_4(\frac{1}{5}\sum_{j=0}^{4}(Top1 \times \alpha)_{i,t-5+j}) + \omega_i + \eta_t + \varepsilon_{i,t},\end{aligned} \tag{7}$$

where ω_i and η_t are the vectors of fixed country and year effects and $\varepsilon_{i,t}$ is the overall error term.

Reduced-form panel growth regression I

- Parsimonious growth regression for three reasons
  1. We don't know what the "true" regression is
  2. We capture an association irrespective of the controls
  3. Data difficult to come by for the early 20th century
- Previous empirical literature: "convergence term" is a regular customer, controls vary
- A set of most-used controls can be identified and we experiment with them
  - Investment, avg educ. att., population growth, debt, openness,...
  - We lose observations and therefore prefer equation (7)

Regardless of the shenanigans we pull, we cannot establish a causal interpretation and need the model to understand our empirical findings

Estimation

We prefer fixed effects estimator

- Rely on within-country variation
- Bengtsson and Waldenström (2018):
  "most of the time series are consistent within countries, whereas the comparability across countries is lower"

Also:

- Pooled OLS and random effects as a robustness check
- Could experiment with GMM estimators but
  - Not suitable with large T and small N (instrument proliferation)
  - More profoundly...

Taken from: https://twitter.com/PHuenermund/status/1303676676140863490/photo/1

Main result I

Table: Top 1 % share, capital share and the growth of per capita GDP

Dependent variable: growth of per capita GDP. Fixed effects panel regression, year dummies included. Column (5) corresponds to equation (7).					
	(1)	(2)	(3)	(4)	(5)
Initial *lnY* (β_1)	-0.0359***	-0.0360***	-0.0371***	-0.0370***	-0.0387***
	(0.0080)	(0.0079)	(0.0087)	(0.0085)	(0.0064)
*Top*1 (β_2)		-0.0217		0.0112	0.6032**
		(0.1044)		(0.1101)	(0.2073)
α (β_3)			-0.0797*	-0.0808*	0.1554
			(0.0402)	(0.0429)	(0.1034)
*Top*1 $\times$ α (β_4)					-2.1448**
					(0.9307)
Constant	0.3291***	0.3334***	0.3641***	0.3623***	0.3169***
	(0.0684)	(0.0654)	(0.0803)	(0.0747)	(0.0629)
Observations	230	230	230	230	230
Number of countries	13	13	13	13	13
Robust standard errors in parantheses. *, ** and *** indicate statistical significance at 10 %, 5 % and 1 % levels, respectively					

Main result II

- Inequality is *positively* associated with growth when α is *small*
- Inequality is *negatively* associated with growth when α is *large*

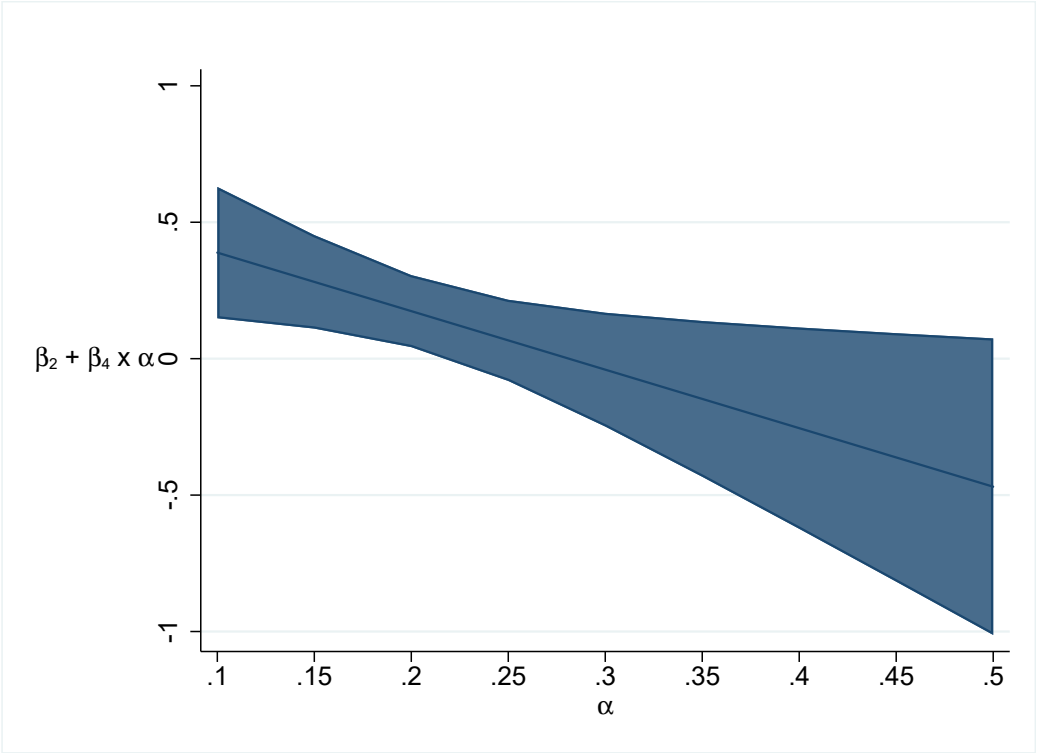

Figure: Association between growth and top 1 % share cond. on capital share

Main result III

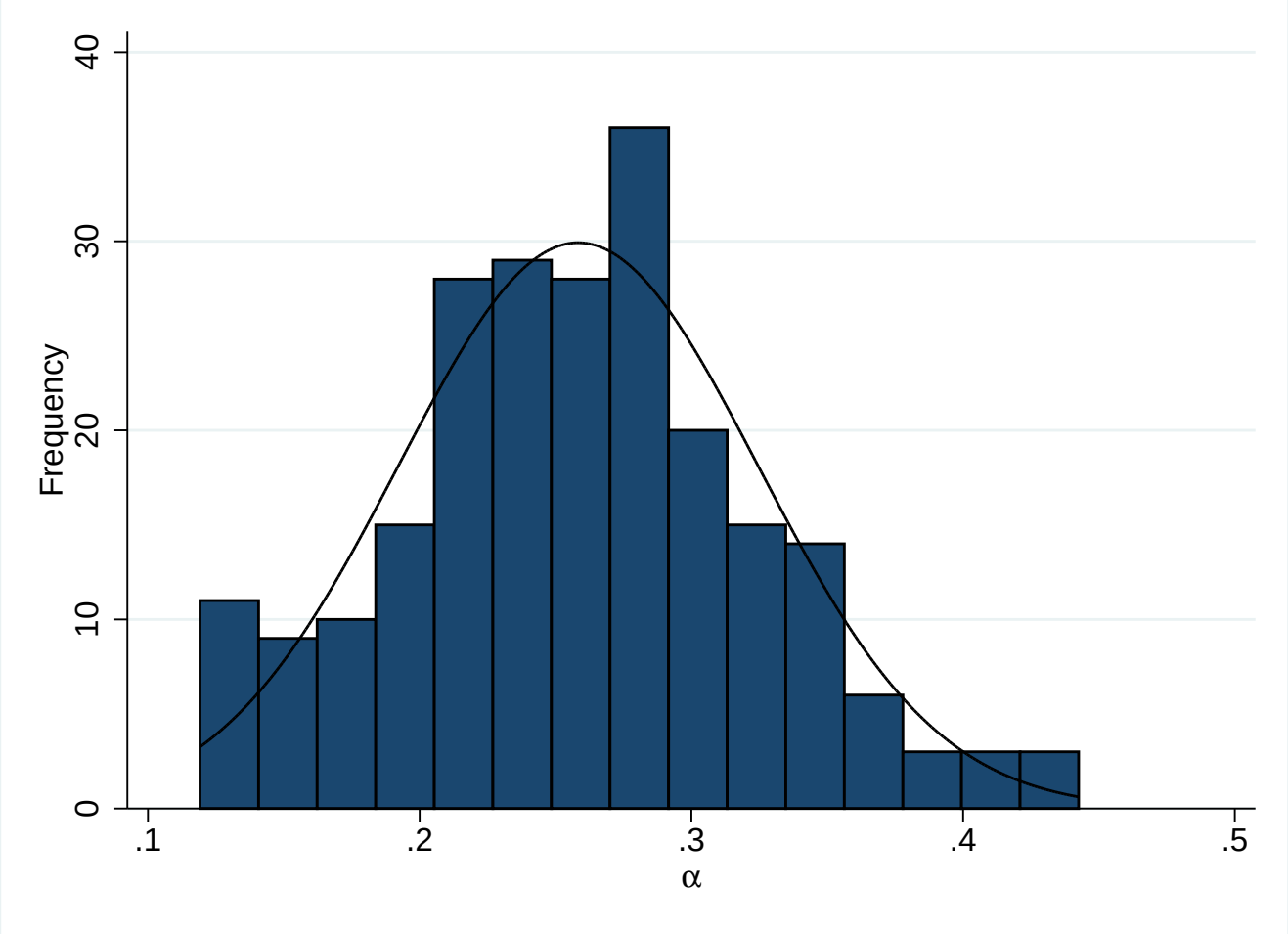

Figure: Distribution of capital shares

Are we capturing dependency to the level of inequality?

Positive association between capital shares and top income shares:
$\beta_3 Top1^2$ instead of $\beta_3\alpha + \beta_4(Top1 \times \alpha)$?
Flat profile instead of a down-ward sloping line

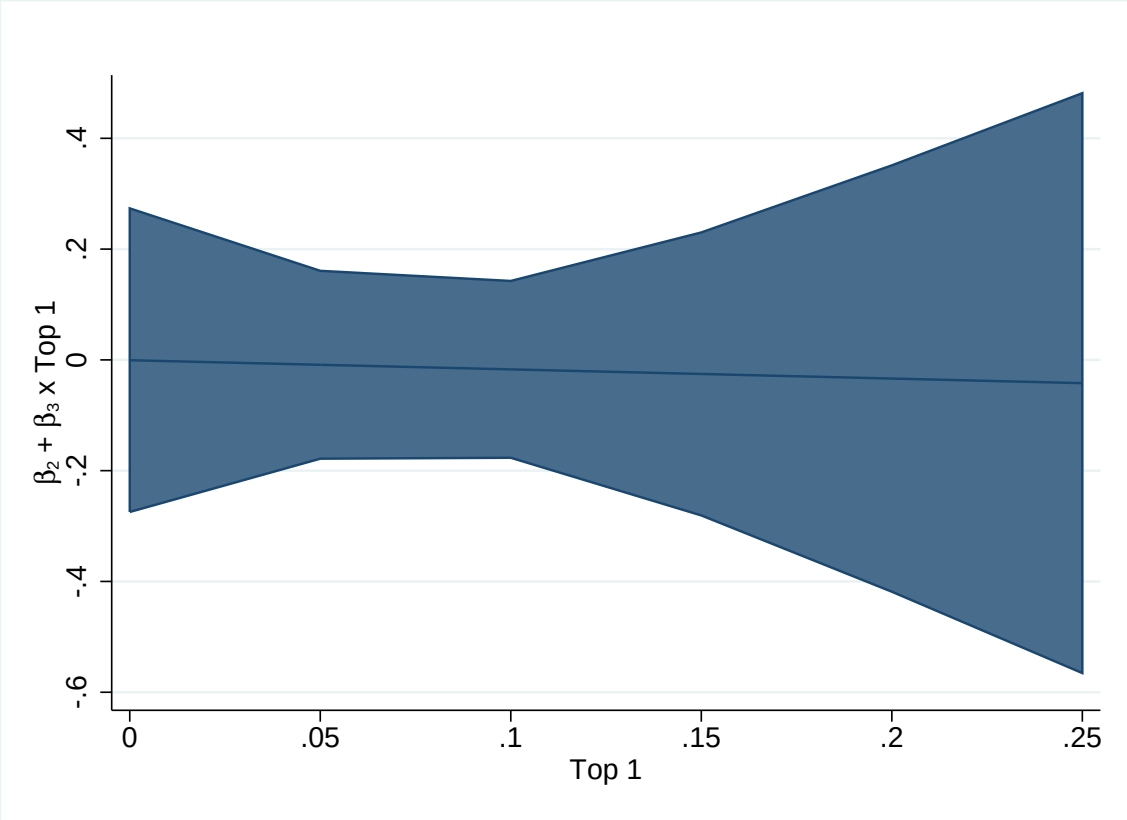

Figure: Association between growth and top 1 % share cond. on top 1 % share

The role of credit constraint I

Rajan and Zingales (2003) and Kuvshinov and Zimmermann (2019) show that numerous proxies for credit constraint were at low levels between 1950 and 1980

- deposits per GDP, stock market capitalization per GDP, funds raised through public equity offerings per investments, ...

Theory (Aiyagari, 1994) predicted

1. a down-ward sloping profile when credit constraint is not binding
2. an up-ward sloping profile when credit constraint is binding

Do we find a down-ward sloping profile pre-1950 and post-1980, and an up-ward sloping profile 1950-1980?

The role of credit constraint II

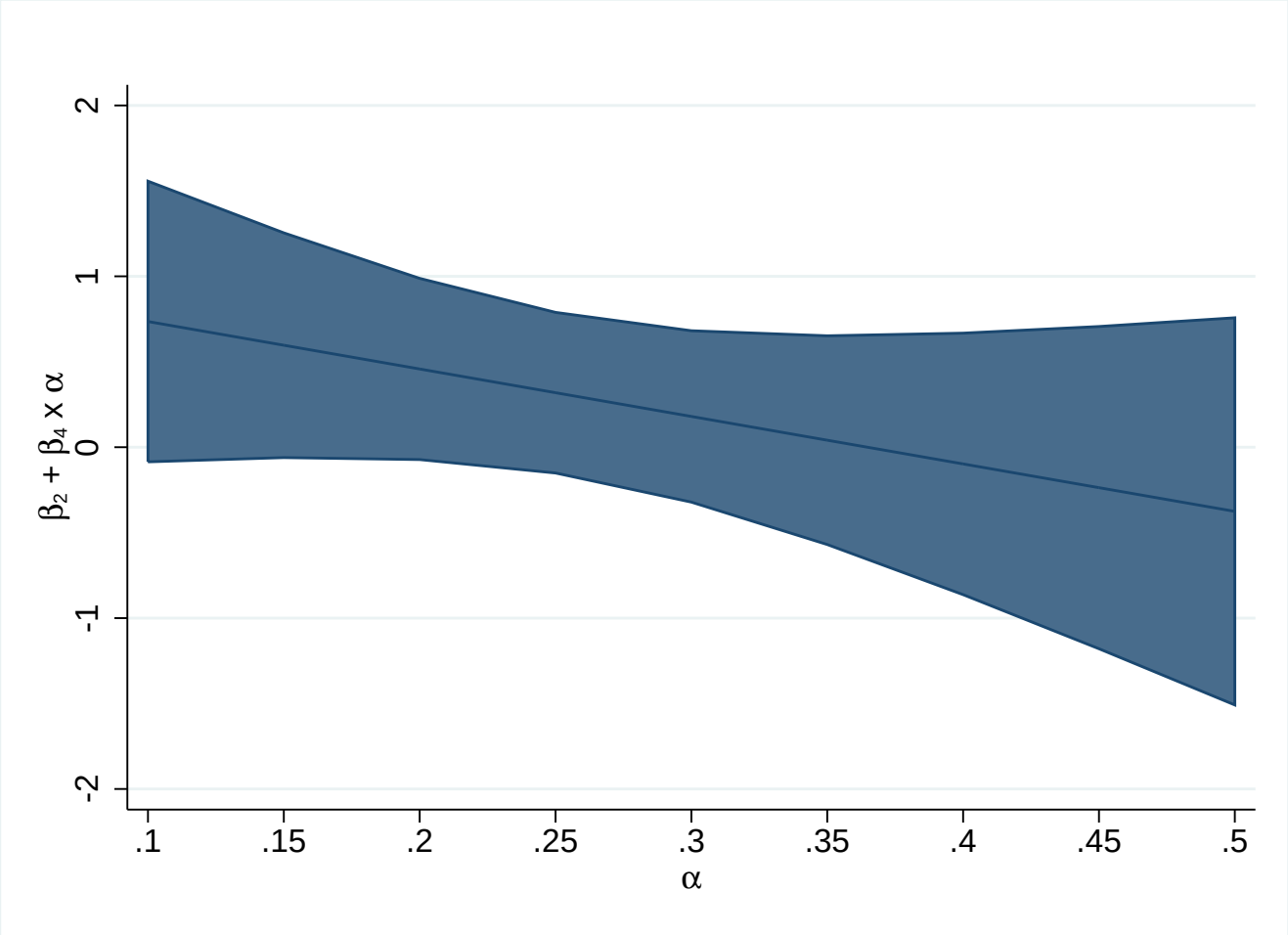

Figure: Growth and top 1 % share cond. on capital share, 1900-1945 (67 obs)

The role of credit constraint III

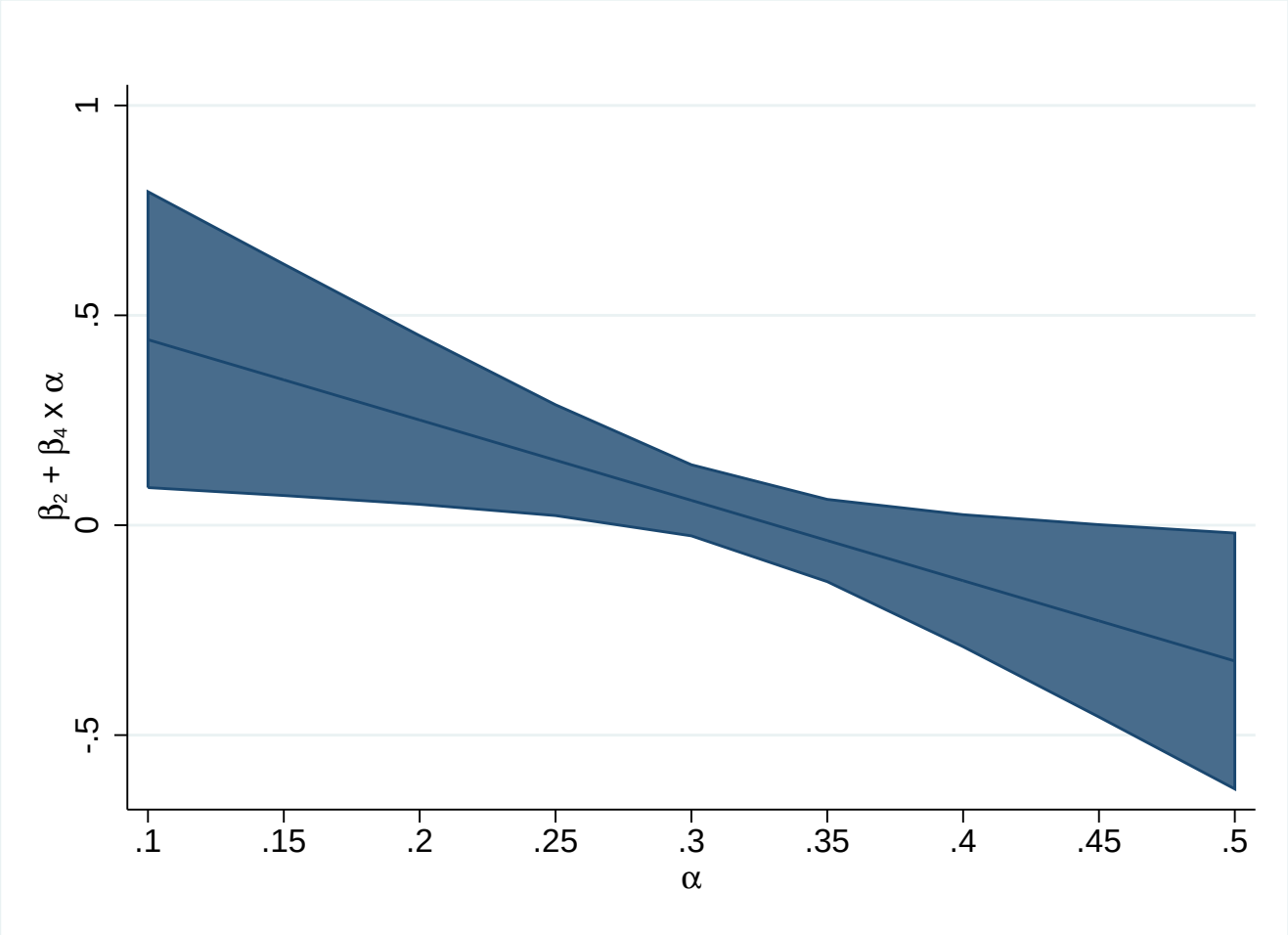

Figure: Growth and top 1 % share cond. on capital share, 1985-2010 (75 obs)

The role of credit constraint IV

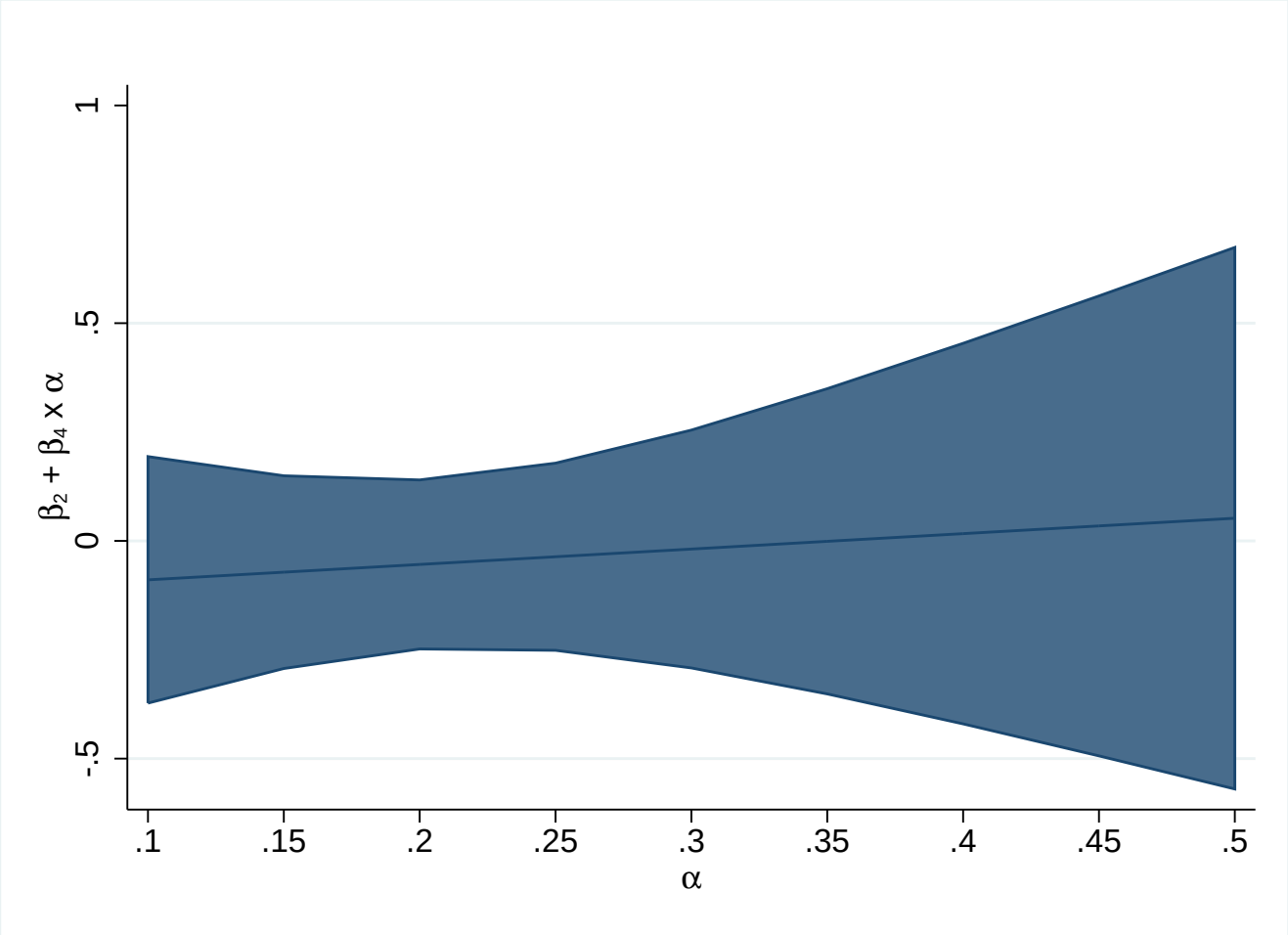

Figure: Growth and top 1 % share cond. on capital share, 1950-1980 (88 obs)

Robustness of our results

Numerous deviations from our preferred specification

- Additional controls
- Drop time dummies and / or the linear capital share term
- Top 10 % and top 0.1 %
- Use capital shares gross of capital depreciation
- Control for the extent of inequality (piece-wise regressions)
- Average annual growth instead of annualized growth during the window
- POLS and RE

Wrapping up I

Our contribution

- The association between personal income distribution and growth is conditional on the functional income distribution
- Theory: operates through capital accumulation & credit constraint matters
- Empirics: robust association consistent with theoretical predictions

Wrapping up II

Limitations of our study / future research

- Well-known limitations of growth regressions
- Not possible to categorize the countries into low/high α economies
  - Ideally, low and high α subsamples
- Room for policy recommendations?
  - Evidence relies on a panel of countries while policies controlled by individual countries: calls for country-specific work (applies generally)
  - The world has changed a lot in comparison to the historical data we use
  - Even in the absence of the above, "increase/reduce inequality!" is not a practically relevant policy recommendation
- Conceptual frameworks that go beyond capital accumulation?

Capital shares revisited: difficult to group countries

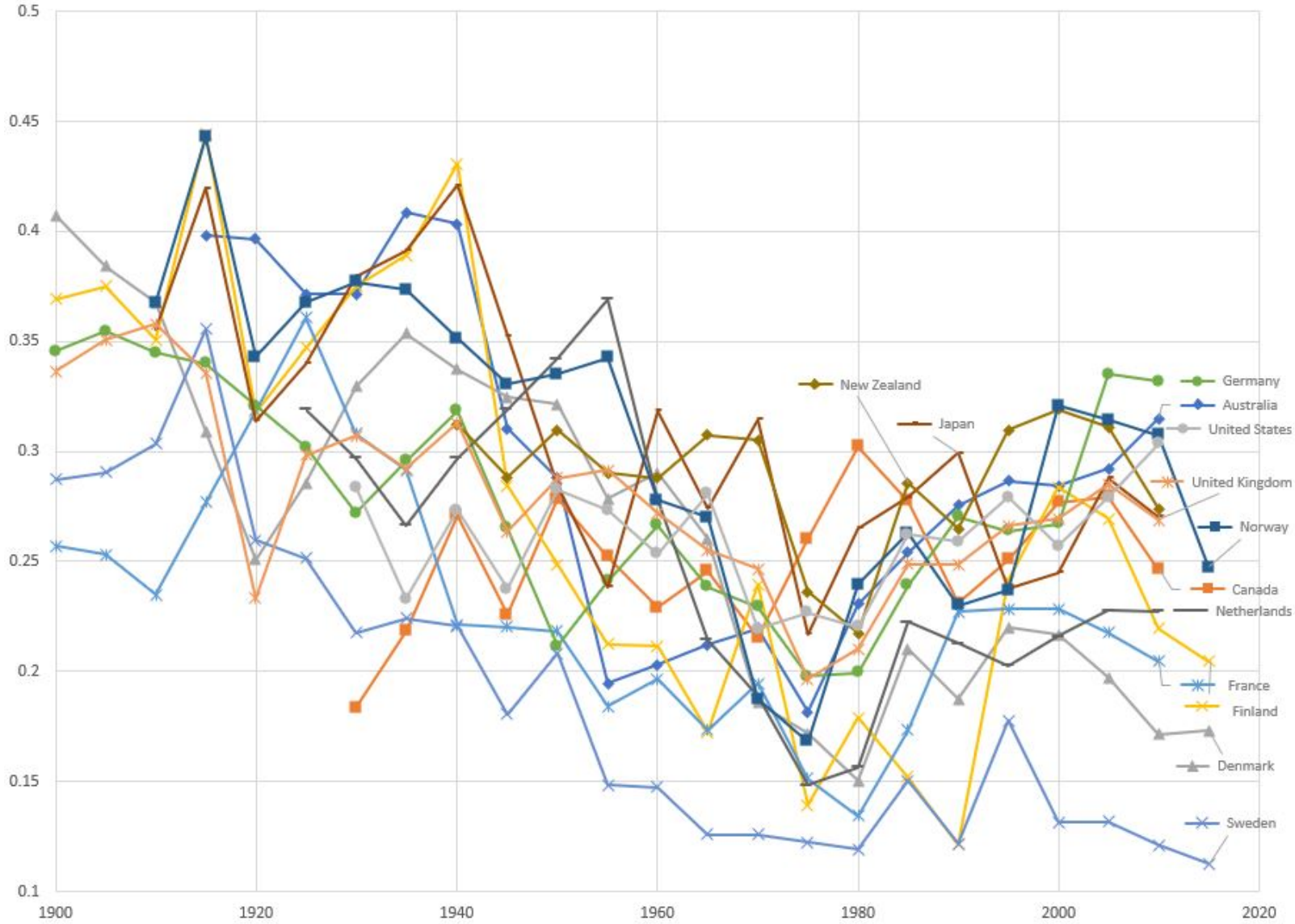

Figure: Capital share of total national income

Some of the focal inequality-growth studies I

Theoretical work

- Convex savings function: Kaldor (1957) and Bourguignon (1981)
- Human capital and the relevance of physical/human in the process of econ. devel.: Galor and Zeira (1993) and Galor and Moav (2004)
- Leaky bucket: Okun (1975), Alesina and Rodrik (1994) and Persson and Tabellini (1994)
- Instability: Alesina and Perotti (1996)

Some of the focal inequality-growth studies II

Empirical cross-country work, typically panel data

- Meta-analysis: Neves et al. (2016)
- Early cross-sec. studies: Alesina and Rodrik (1994) and Perotti (1996)
- Dependency to the level of economic development: Barro (2000)
- "Any change is bad change": Banerjee and Duflo (2003)
- Short-run and long-run growth responses: Halter et al. (2014)
- Inequality, redistribution and growth: Ostry et al. (2014)

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