Wealth equality in the long run: A Schumpeter growth perspective

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Overview

- Great interest for the income inequality-growth nexus (Aghion et al. 1999, Cingano 2014)
- Rich evidence on factors explaining the decline in labour share, i.e. technical change, innovation and intangibles (Elsby et al. 2013; Karabarbounis and Neiman 2014; Koh et al. 2016; O'Mahony et al. 2017).
- Increasing number of studies looking at the link between innovation and top income inequality (Jones and Kim 2015, Aghion et al. 2015; Paunov and Guellec 2017)
- Little interest on the link innovation-wealth inequality (Piketty and Zucman 2014)

The "fundamental laws" of capitalism

First law

$$\alpha^K = r \times \frac{K}{Y} = r \times \beta$$

- r is net real rate of return on capital (or wealth)
- $\beta \equiv K/Y$ is aggregate capital (wealth) stock, K, over income, Y.

$\Rightarrow$ Given r, the share of income accruing to capital owners, α^K, rises as the capital-to-income ratio rises (β).

The "fundamental laws" of capitalism, cont'ed

Second law

$$\beta = \frac{K}{Y} = \frac{s}{g}.$$

In the long run the wealth-income ratio is driven by the ratio between of the saving rate, s, and the rate of income growth, g.

Criticism in summary

- **Severe criticism** to Piketty's theory (implausible assumptions on elasticity of substitution or on net/gross variables, no institutions, driving role of housing, measurement issues, etc.).
- Most criticism induced by the **lack of economic structure**, and no mention to **mechanisms or incentives** driving wealth accumulation and income growth
- R&D treated **similarly** to investment in physical assets (see P&Z, 2014, QJE, p. 1267).

Contribution of the work (1)

- We characterize Piketty's fundamental laws of capitalism within a Schumpeterian (R&D based) growth setting extended to include CAPITAL (Grossman and Helpman 1991)
- We study econometrically the drivers of wealth inequality through a regression analysis on 21 OECD countries between 1860 and 2015 addressing an array of issues (strong cross-sectional dependence, omitted variables, simultaneity issues, heterogeneity)

THE MODEL: GH (1991) WITH CAPITAL

Final good production

1. A homogeneous final good, Υ, is produced under perfect competition and can be consumed by households or purchased by firms as capital equipment.

2. Constant-returns Cobb-Douglas production function

$$\Upsilon = A_{\Upsilon} L_{\Upsilon}^{1-\zeta-\eta} K^{\zeta} D^{\eta}, \quad \text{with} \quad 0 < \zeta, \eta, \quad \text{and} \quad \zeta + \eta < 1,$$

- A_{Υ} is a constant reflecting the choice of units;
- K denotes the aggregate capital stock;
- D represents an index of innovative (intermediate) inputs;
- L_{Υ} is the total employment in final good production.

Intermediate goods production

$$\log D \equiv \int_0^1 \log \left[\sum_j q_j(\omega) d_j(\omega) \right] d\omega,$$

- $d_j(\omega)$ represents the input of quality j of innovative (intermediate) product ω;
- Quality j of product ω is denoted as $q_j(\omega) = \lambda^j$, where $\lambda > 1$ represents the size of the quality increment;
- One unit of labor is needed to manufacture one unit of output, regardless of quality;
- Limit price set by the monopolistic firm (i.e. the one with the state-of-the-art quality product): $p = \lambda w$.

R&D sector

1. The R&D sector is characterized by a perfect competition, free entry and constant returns to scale.
2. Incentives to do R&D come from the following condition:

$$\begin{aligned} v &= \underbrace{w}_{=1} a_l \\ \textit{marginal return} &= \textit{marginal cost} \end{aligned}$$

- v denotes the expected reward for winning an R&D race, i.e. the (stock market) value of innovation;
- a_l units of labor employed in R&D per unit of time;
- Wage rate w normalized to 1.

Growth equation

$$g_{\Upsilon} = \dot{\Upsilon}/\Upsilon = \frac{\eta}{1-\zeta} \underbrace{\iota} \log \lambda$$

The rate of income growth, g is endogenous:

- ι rate of innovation (i.e. outcome of R&D activities)
- λ quality jump of innovative (intermediate) product
- η income share of innovative (intermediate) input;
- ζ income share of capital

In equilibrium, the rates of output, consumption and investment growth are identical g:

$$g = g_{\Upsilon} = g_K = g_C$$

Key eq: Wealth-income

The value of the net wealth-income ratio is:

$$\beta \equiv \frac{W}{Y - \delta K} = \frac{K + v}{Y - \delta K}.$$

In steady state, wealth inequality can be expressed as:

$$\beta = \underbrace{\frac{s_K}{g_\Upsilon}}_{Piketty} + \underbrace{\frac{s_{R\&D} \cdot k}{g_\Upsilon}}_{Schumpeter} \tag{1}$$

in which k is a collection of parameters ($k = \frac{\eta}{1-\zeta} \log \lambda$).

Predictions

- β increases with the share of GDP accruing to capital investment and R&D (**larger rewards to factor owners**)
- β decreases with a faster rate of economic growth (**resource distribution**)
- However, as g depends on the rate of innovation (i.e. the rate of R&D success), β decreases with research productivity as **more successful R&D destroys incumbents' rents**.

$\Rightarrow$ Room for **positive public policies** promoting income growth, e.g. by raising R&D productivity or efficiency (IPR, competition policies, see Paunov and Guellec 2017)

Empirical specification

We estimate this model as a log-linear specification:

$$\ln \beta = \eta_{0i} + \eta_1 \ln s_{R\&D,it} + \eta_2 \ln s_{K,it} + \eta_3 \ln g_{it} + \epsilon_{it},$$

- We expect that $\eta_1 > 0$, $\eta_2 > 0$ and $\eta_3 < 0$.

Cross-sectionally augmented distributed lag (CS-DL) approach (Chudik et al. 2016)

Let us consider a **long-run** relationship

$$y_{it} = \theta x_{it} + \epsilon_{it}$$

CS-DL estimates the following

$$y_{it} = \theta x_{it} + \beta \sum_{p=0}^{P_x} \Delta x_{it} + \omega_{yp} \sum_{p=0}^{P_y} \overline{y}_{it-p} + \omega_{xp} \sum_{p=0}^{P_x} \overline{x}_{it-p} + \tilde{\epsilon}_{it}$$

Δx_{it} purges the effect of short-run feedbacks
$\overline{y}$ and $\overline{x}$ purges the effect of unobserved factors (cross-sectional dependence).

Properties of the estimator

1. CS-DL performs better than other dynamic estimators (such as ARDL) when short sample;
2. Robust to error serial correlation, cross-sectional dependence, dynamic misspecification, breaks in the error processes, non-stationarity;
3. However, CS-DL suffers from feedbacks from x's on y. Valid alternatives are:
   $\Rightarrow$ Auto-regressive Distributed Lags (ARDL) model

   $\Rightarrow$ IV regression

Country and time coverage

1. Country coverage: 21 OECD countries (Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, US);
2. Time span: 1860-2015;
3. Variables are expressed in gross terms and constant prices (departure from Piketty).

Summary

Variable	Definition	Data
β	Wealth/income	(R&D + capital stocks) /GDP Stock market capitalization/GDP
$s_{R\&D}$	R&D investment rate	R&D investment/GDP
s_K	Capital Investment rate	Capital investment/GDP (structures and equipment)
g	Income growth	GDP or GDP per capita growth (adjusted for capital depreciation)
δ	Depreciation rate	Weighted average of depreciation rates of R&D and capital stocks
Controls	Financial development Macroeconomic instability Fiscal burden Trade openness	Bank credit/GDP Inflation rate Direct taxation/GDP (Import+Export)/GDP

Further details

1. Real GDP is expressed in 1990 dollars valued at PPP;
2. R&D and physical stocks obtained through the perpetual inventory method:
    - depreciation rate of 15% for R&D expenses, 17% for equipment and 3% for structures.

Summary statistics

Table: **Summary statistics, 1860-2015**

		TOTAL SAMPLE			COUNTRY PERFORMANCE			
		Mean	SD	Median	Max		Min	
Wealth-income ratio, β								
R&D stock/GDP		0.039	0.048	0.012	USA	0.066	PRT	0.010
Capital stock/GDP		1.496	0.775	1.498	FRA	2.497	PRT	0.335
(R&D + Capital stocks)/GDP		1.535	0.781	1.551	FRA	2.553	PRT	0.345
Stock market capitalization/GDP		32.7	44.4	20.0	GBR	125.0	PRT	0.08
Saving/investment rate								
R&D investment/GDP	$s_{R\&D}$	0.007	0.009	0.003	USA	0.012	PRT	0.002
Capital investment/GDP	s_K	0.026	0.060	0.013	ITA	0.091	GER	-0.022
(R&D + Capital investment)/GDP	$s_{R\&D}+ s_K$	0.033	0.059	0.020	ITA	0.095	GER	-0.012
Income growth								
GDP	g	0.016	0.045	0.017	FIN	0.021	NZL	0.011
GDP + depreciation	$(g+\delta)$	0.110	0.050	0.110	CAN	0.116	IRE	0.098

Organization of estimates

- Baseline estimates (measurement)
- Robustness checks (control variables)
- Time pattern (time intervals)
- Multidimensional heterogeneity (across country and time)
- Simultaneity issues (IV estimates; preliminary)
- Short-run feedbacks (panel VAR; preliminary)

Benchmark estimates and control variables

		1	2	3	4	5	6
R&D investment/GDP	$s_{R\&D}$	0.029***	0.033***	0.028***	0.030***	0.031***	0.025***
		(0.010)	(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Capital investment/GDP	s_K	0.155***	0.152***	0.155***	0.153***	0.140***	0.132***
		(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Income growth	g'	-0.051***	-0.051***	-0.051***	-0.049***	-0.049***	
		(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	
Bank credit/GDP			0.077***				
			(0.007)				
Inflation rate				0.001			
				(0.007)			
Taxation rate					-0.091***		
					(0.009)		
Trade openness						0.023	
						(0.027)	
Patenting rate							-0.145***
							(0.026)
Obs.		3,276	3,276	3,276	3,276	3,068	3,269
R-squared		0.319	0.342	0.319	0.342	0.288	0.297

Notes: SE in parentheses. Variables in logs. Capital investment includes non-residential structures and equipment. Capital aggregates based on base-year indexes. Variables are gross of capital depreciation. ***, **, * significant at 1, 5 and 10%.

Effects over different time intervals

		1	2	3	4
		1860-2015	1860-1945	1945-2015	1970-2015
R&D investment/GDP	$s_{R\&D}$	0.029***	0.089***	0.054***	0.149***
		(0.010)	(0.012)	(0.010)	(0.014)
Capital investment/GDP	s_K	0.154***	0.045***	0.668***	0.761***
		(0.007)	(0.005)	(0.017)	(0.024)
Income growth	g'	-0.050***	-0.025***	-0.047***	-0.632***
		(0.005)	(0.003)	(0.005)	(0.056)
Obs.		3,276	1,785	1,470	945
R-squared		0.318	0.283	0.635	0.714

Notes: SE in parentheses. Variables in logs. Capital investment includes non-residential structures and equipment.

Capital aggregates based on base-year indexes. Variables are gross of capital depreciation.

***, **, * significant at 1, 5 and 10%.

Parameter heterogeneity across countries / time (1860-2015)

		1	2	3
R&D investment/GDP	$s_{R\&D}$	0.029**	0.064*	0.144***
		(0.009)	(0.032)	(0.010)
Capital investment/GDP	s_K	0.154***	0.200***	0.277***
		(0.007)	(0.059)	(0.015)
Income growth	g'	-0.050***	-0.019**	-0.066***
		(0.005)	(0.009)	(0.025)
Heterogeneity		No	Country	Country/Time
CSD		CCE	CCE	CCE
Estimator		OLS	MG-OLS	MO-OLS
Observations		3,276	3,066	3,276

Notes: SE in parentheses. Variables in logs. Capital investment includes non-residential structures and equipment. Capital aggregates based on base-year indexes. Variables are gross of capital depreciation.
***, **, * significant at 1, 5 and 10%.

Homogeneous parameters: $y_{it} = \theta x_{it} + \epsilon_{it}$
Heterogeneous across countries: $y_{it} = \theta_i x_{it} + \epsilon_{it}$ (Chudik et al. 2016)
Heterogeneous across countries and time: $y_{it} = \theta_{it} x_{it} + \epsilon_{it}$ in which $\theta_{it} = \theta_i + \theta_t$ (Neal 2016)

Simultaneity issues

- **ARDL**: consistent estimates in dynamic setting (Chudik et al. 2016)
- **IV estimates**: impact of endogenous variables predicted using external instruments within a static (first-step) specification and predicted values used in our dynamic (CSDL) model, bootstrapping standard errors (Bloom et al. 2013)

IV estimates

- The impact of $s_{R\&D}$ and s_K is predicted exploiting variation in natural disasters that hit the other countries of the sample from 1900 (source: EM-DAT).
- Natural disasters are of various types (earthquake, storms, etc.) and can be classified into two main groups: geological and climatic (Skidmore and Toya 2002).
- The number of natural disasters are weighted by the inverse of the distance between countries (source: CEPII)
- Identification: External disasters reduce demand for domestic products and thus incentives to invest **at home**, lowering income growth (Fomby et al. 2013).
- Income growth is endogenous to innovation and hence is predicted by the rate of patenting (domestic and foreign).

ARDL and IV estimates

		1	2	3	4	5
		CSDL	ARDL	CSDL	CSDL	CSDL
				Instrumented - 2nd STEP		
				$s_{R\&D}$	s_K	g
R&D investment/GDP	$s_{R\&D}$	0.029***	**0.200***	**0.220****	0.052***	0.029**
Capital investment/GDP	s_K	0.154***	**0.335*****	0.142*	**0.122***	0.129***
Income growth	g	-0.050***	**-0.143*****	-0.050***	-0.016***	**-0.141*****
				1st STEP		
Instrument 1				-0.009***	-0.014***	0.020***
Instrument 2				-0.028***	-0.020***	-0.004***
				F-test		
				19.79	11.35	12.00
				Land movements Climatic	Landslides Storms	Dom. patenting Foreign patenting
Obs.		3,276	2,436	2,436	2,436	2,436
R-squared		0.319	0.988	0.293	0.198	0.222

Variables in logs. Country-specific FE included. ***, **, * significant at 1, 5 and 10%.

Summary of results (long run)

- Theory: Piketty theory characterized within a Schumpeterian growth framework
- Empirics (long run): Wealth-to-income driven by research investment. However, when successful, R&D delivers more innovations and these promote growth and reduce β
- Policy implications: Need to remove factors reducing research efficiency (*product/labour/financial market regulation*) and to increase research quality (*better higher education system*). Unreported short-run VAR analysis indicates expansionary policies expanding g have only temporary effects on wealth inequality.

Thanks for your attention

β in the short run (1970-2015) VAR analysis (1)

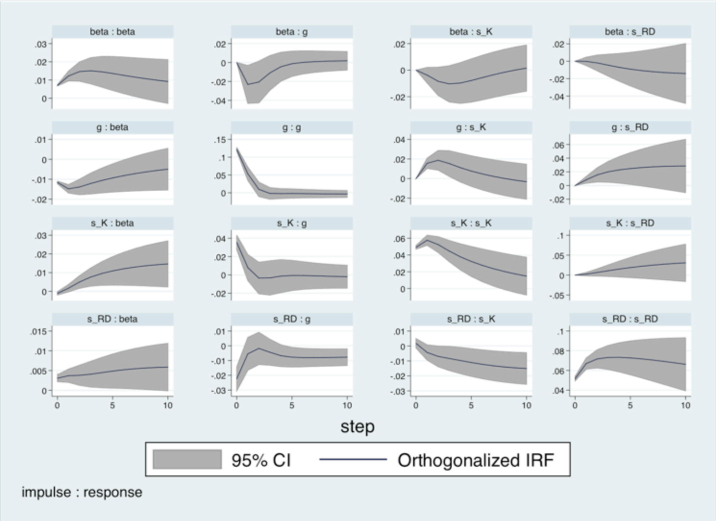
Granger-causality test

Dep: $s_{R\&D}$	chi2	df	p-value
s_K	2.279	2	0.320
g	4.146	2	0.126
β	0.346	2	0.841
ALL	14.75	6	0.0220
Dep: s_K			
$s_{R\&D}$	2.357	2	0.308
g	7.665	2	0.022
β	9.452	2	0.009
ALL	112.161	6	0.000
Dep: g			
$s_{R\&D}$	10.685	2	0.005
s_K	1.524	2	0.467
β	9.125	2	0.010
ALL	45.253	6	0.000
Dep: β			
$s_{R\&D}$	11.367	2	0.003
s_K	6.162	2	0.046
g	5.777	2	0.056
ALL	41.254	6	0.000

H0: the explanatory variable(s) do(es) not Granger-causa the dependent variable

β in the short run (1970-2015) VAR analysis (2)

Orthogonalized Impulse Response Function



β in the short run (1970-2015) - VAR analysis (3)

Forecast-error variance decomposition (FEVD)

Dep: $s_{R\&D}$	$s_{R\&D}$	s_K	g	β
0	0.000	0.000	0.000	0.000
1	1.000	0.000	0.000	0.000
2	0.990	0.001	0.009	0.000
...				
5	0.931	0.016	0.050	0.003
10	0.840	0.061	0.086	0.013
Dep: s_K	$s_{R\&D}$	s_K	g	β
0	0.000	0.000	0.000	0.000
1	0.001	0.999	0.000	0.000
2	0.004	0.954	0.040	0.002
...				
5	0.018	0.890	0.071	0.021
10	0.062	0.856	0.059	0.022
Dep: g	$s_{R\&D}$	s_K	g	β
0	0.000	0.000	0.000	0.000
1	0.030	0.075	0.894	0.000
2	0.026	0.066	0.881	0.027
...				
5	0.029	0.064	0.854	0.053
10	0.043	0.064	0.841	0.052
Dep: β	$s_{R\&D}$	s_K	g	β
0	0.000	0.000	0.000	0.000
1	0.048	0.006	0.689	0.257
2	0.040	0.007	0.610	0.343
...				
5	0.039	0.092	0.422	0.447
10	0.057	0.259	0.282	0.401

Short-run results

- Empirics: β particularly sensitive to shocks income growth (expansive public policies). This effect vanishes over time (halved after 10 years). Shocks in s_K increase β; however, they also strongly impact on g and hence the detrimental effect of s_K on wealth inequality is somehow reduced. Small effects of shocks in $s_{R\&D}$ on g but not g.
- Policy implications: Expansive policies very short-lived. This confirms importance of structural policies.