Capital Depreciation and Labor Shares Around the World: Measurement and Implications

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Introduction

- Recent work has shown pervasive global decline in labor share of *gross* production ("gross labor share")
- Important implications for the shape of production function, growth and technology, and fluctuations
- Labor share of *net* production ("net labor share") may be more important for inequality as depreciation is not consumed

Three Questions

1. How did the net labor share evolve?
   - Globally, the net labor share declined together with the gross
   - U.S. is outlier – net declined about half as much as gross
2.
   -
   -
3.
   -
   -

Three Questions

1. How did the net labor share evolve?
   - Globally, the net labor share declined together with the gross
   - U.S. is outlier – net declined about half as much as gross
2. What do we learn from these joint movements?
   - Declining price of capital goods consistent with both labor shares declining
   - Not generally true for other shocks (interest rate, sec. stag.)
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Three Questions

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   - Globally, the net labor share declined together with the gross
   - U.S. is outlier – net declined about half as much as gross
2. What do we learn from these joint movements?
   - Declining price of capital goods consistent with both labor shares declining
   - Not generally true for other shocks (interest rate, sec. stag.)
3. Which labor share should we use?
   - Measurement issues
   - Even if you care only about inequality, during transitional dynamics it is not obvious that net is a preferable measure

Related Literature

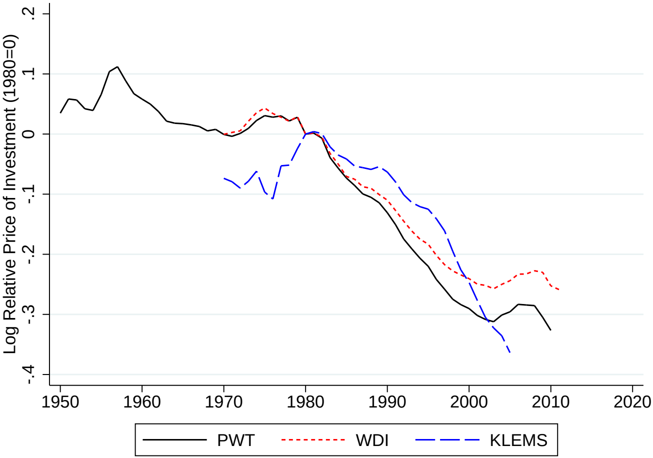
- Labor Share: Blanchard (1997); Gollin (2002); Karabarbounis and Neiman (2014); Piketty and Zucman (2014).
- Estimating the Elasticity of Substitution: Antras (2004); Chirinko (2008); Karabarbounis and Neiman (2014); Piketty and Zucman (2014); Oberfeld and Raval (2014).
- Depreciation and Labor Shares, Growth, and Inequality: Weitzman (1976); Piketty (2014); Krusell and Smith (2014); Bridgman (2014), Rognlie (2014), Summers (2014).

Agenda

- Background from Karabarbounis and Neiman (QJE 2014)
- Measurement and Empirics of Labor Shares and Depreciation
- A Simple Three Sector Model
- Depreciation and Labor Shares across Steady States
- Depreciation, Labor Shares, and Inequality during Transitions
- Next Steps

Background: Pervasive Global Labor Share Decline

Background: Investment Price (ξ) Caused the Decline



Background: Cross-sectional Pattern Implies $\sigma > 1$

$$\frac{s_{L,j}}{1 - s_{L,j}} \hat{s}_{L,j} = \gamma + (\sigma - 1)\, \hat{\xi}_j + u_j.$$

s_L **Data**	ξ **Data**	$\hat{\sigma}$	**S.E.**	**90% CI**	**Obs.**
KN Merged	PWT	1.25	0.08	[1.11,1.38]	58
KN Merged	WDI	1.29	0.07	[1.18,1.41]	54
OECD/UN	PWT	1.20	0.08	[1.06,1.34]	50
OECD/UN	WDI	1.31	0.06	[1.20,1.42]	47
KLEMS 1	KLEMS	1.17	0.06	[1.06,1.27]	129
KLEMS 2	KLEMS	1.49	0.13	[1.28,1.70]	129

Background

- Robustness in Karabarbounis and Neiman (2014)
  - Compositional changes ▸ Details
  - Accounting for Markups ▸ Details
  - Biased technological change ▸ Details
  - Capital-skill complementarity ▸ Details

- Piketty, and Piketty and Zucman (2014), also support $\sigma > 1$. Forecast rise in *net* capital shares and, therefore, inequality.

- Bridgman (2014) and Rognlie (2014) look at U.S. and question extent of *net* labor share decline

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Key Data Sources

- System of National Accounts, "Detailed National Accounts":
  - Subject to "smooth pasting", we combine: Internet (preferred); UN and OECD electronic databases; UN and OECD books.
  - Five Sectors: Financial and non-financial corporate (C), Government (G), and Households and Non-Profits (H)
- Focus on Corporate Sector Whenever Possible:
  - Avoids imputation from "mixed income" (Gollin 2002)
  - Less sensitive to measurement of residential housing (Bonnet et al. 2014, Jones 2014, Rognlie 2014, Acemoglu-Robinson 2014)
- Penn World Tables 8.0 (PWT)
  - Greater country coverage (can't focus on corporate sector)
  - Consistent depreciation across countries (Inklaar-Timmer 2013)

How is Depreciation Measured?

- National Accounts (generally)
  - Type j capital depreciation rate δ^j calculated from resale prices
  - δ^j fixed over time
  - Aggregate depreciation rate δ is a weighted-average of the δ^j's and changes *only* due to composition
- PWT uses U.S. estimates of δ^j for all countries

How is Depreciation Measured?

Type of Asset	Rate of depreciation	Service life (years)	Declining balance rates	Hulten-Wykoff category [1]
Private nonresidential equipment				
Software:				
Prepackaged	0.5500	3	1.65	C
Custom	0.3300	5	1.65	C
Own-account	0.3300	5	1.65	C
Office, computing, and accounting machinery [2]:				
Years before 1978	0.2729	8	2.1832	B
1978 and later years	0.3119	7	2.1832	B
Private nonresidential structures				
Industrial buildings	0.0314	31	0.9747	A
Mobile offices [17]	0.0556	16	0.8892	A
Office buildings [17]	0.0247	36	0.8892	A
Commercial warehouses [17]	0.0222	40	0.8892	A
Other commercial buildings [17]	0.0262	34	0.8892	A
Religious buildings	0.0188	48	0.9024	C
Educational buildings	0.0188	48	0.9024	C
Hospital and institutional buildings	0.0188	48	0.9024	B
Hotels and motels [18]	0.0281	32	0.899	B
Amusement and recreational buildings [18]	0.0300	30	0.899	B
All other nonfarm buildings [18]	0.0237	38	0.899	B
Railroad replacement track [19]	0.0249	38	0.948	C
Other railroad structures [19]	0.0176	54	0.948	C
Telecommunications [19]	0.0237	40	0.948	C

- About 150 categories of capital
- Autos come from R.L. Polk & Co.

Quality?

Four Labor Share Measures

1. $$s_L^{TG} = \frac{\text{Total Compensation of Employees}}{\text{Gross Domestic Product}}$$

2. $$s_L^{TN} = \frac{\text{Total Compensation of Employees}}{\text{Gross Domestic Product} - \text{Total Depreciation}}$$

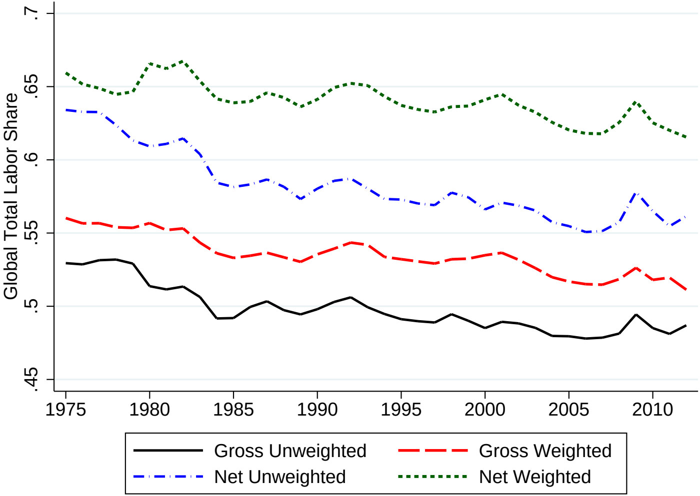
3. $$s_L^{CG} = \frac{\text{Corporate Compensation of Employees}}{\text{Corporate Gross Value Added}}$$

4. $$s_L^{CN} = \frac{\text{Corporate Compensation of Employees}}{\text{Corporate Gross Value Added} - \text{Corporate Depreciation}}$$

"T"=Total, "C"=Corporate, "G"=Gross, and "N"=Net

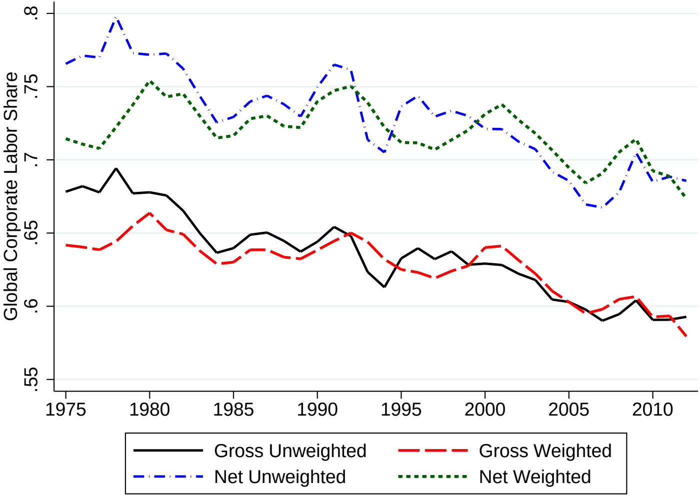
Total Global Labor Share Measures in KN Data

$$s^j_{L,i,t} = \gamma^j_t + \gamma^j_i + \epsilon^j_{i,t}.$$



Corporate Global Labor Share Measures in KN Data

$$s^j_{L,i,t} = \gamma^j_t + \gamma^j_i + \epsilon^j_{i,t}.$$



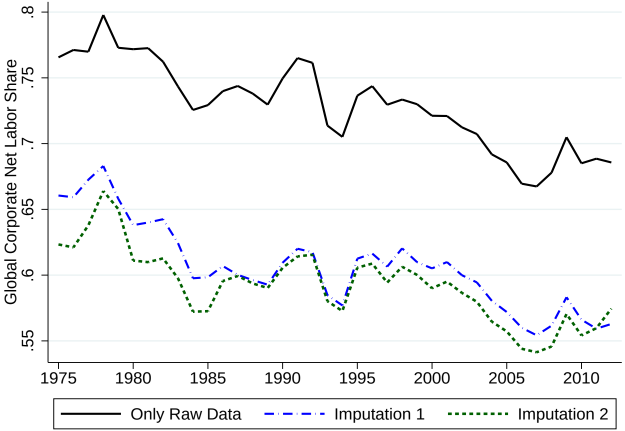
Summary: Global Labor Share Trends

		Percentage Points		Percent		
Data	Labor Share	Unweighted	Weighted	Unweighted	Weighted	Ctys
KN	Total Gross	-4.6	-4.0	-9.1	-7.5	70
KN	Total Net	-7.0	-3.6	-11.9	-5.6	59
KN	Corp. Gross	-9.2	-5.4	-14.5	-8.8	40
KN	Corp. Net	-9.8	-3.7	-13.4	-5.1	29
PWT	Adj. Gross	-8.7	-6.4	-13.7	-10.6	72
PWT	Adj. Net	-9.3	-5.8	-13.0	-8.7	68

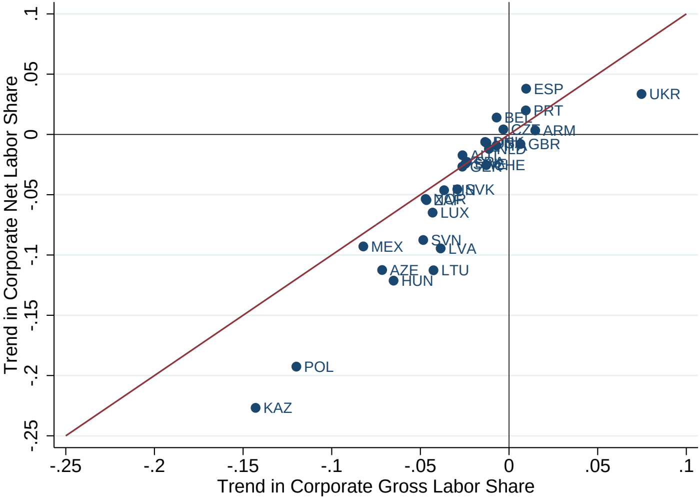
U.S. labor share

Imputing For Countries Without Raw Data

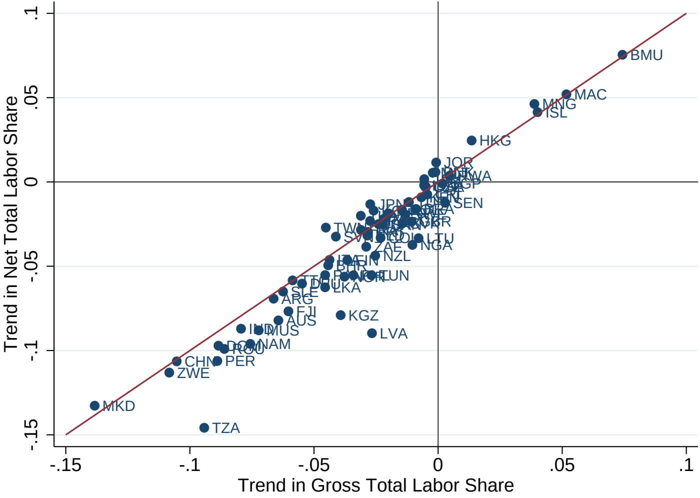
$$\frac{s^{j}_{L,i,t}}{s^{j'}_{L,i,t}} = \eta^{j,j'}_{t} + \eta^{j,j'}_{i} + \epsilon^{j,j'}_{i,t}.$$



Cross-Country Pattern in KN Data



Cross-Country Pattern in PWT Data



Cross-Country Pattern in PWT Data

- Surprising?

Cross-Country Pattern in PWT Data

- Surprising? Shouldn't $\delta\frac{K}{Y}$ increase with $\frac{K}{Y}$?

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A Simple Three Sector Model

Features of environment include:

- Elasticity of substitution between capital and labor $\sigma > 1$
- Heterogeneous types of capital K^j with different δ^j and ξ^j
-

We introduce shocks to:

- Price of investment (ξ),
- Depreciation rate (δ), and
- Real interest rate (r).

We ask:

1. "What is *relative* movement of gross and net labor shares?"
2.

A Simple Three Sector Model

Features of environment include:

- Elasticity of substitution between capital and labor $\sigma > 1$
- Heterogeneous types of capital K^j with different δ^j and ξ^j
- Two types: Hand-to-Mouth Workers and Capitalists

We introduce shocks to:

- Price of investment (ξ),
- Depreciation rate (δ), and
- Real interest rate (r).

We ask:

1. "What is *relative* movement of gross and net labor shares?"
2. "Which measure better proxies for inequality?"

Production

- CES Production:

$$Y_t = \left(\alpha \left(A_{K,t} K_t\right)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)\left(A_{N,t} N_t\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}.$$

- Capital bundle:

$$K_t = \left(\left(K_t^L\right)^{\frac{\theta-1}{\theta}} + \left(K_t^H\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}},$$

- W_t is the rental rate of labor
- R_t^j is the rental rate of capital K^j

Capital Stock Dynamics

- Output is consumed and used as inputs to investment:

$$Y_t = C_t + I_t^L + I_t^H$$

- Investment goods:

$$X_t^j = \frac{1}{\xi_t^j} I_t^j \quad \Longrightarrow \quad p_t^j = \xi_t^j$$

- Law of Motion for Type-j Capital:

$$K_{t+1}^j = \left(1 - \delta^j\right) K_t^j + X_t^j$$

Consumption

- Workers: $C_t^N = W_t N_t$

- Capitalists solve:

$$V_0 = \max_{K_{t+1}^L, K_{t+1}^H, D_{t+1}} \sum_{t=0}^{\infty} \beta^t U(C_t^K)$$

$$C_t^K + \xi_t^L X_t^L + \xi_t^H X_t^H + (1 + r_t) D_t = R_t^L K_t^L + R_t^H K_t^H + D_{t+1}$$

- Aggregate consumption:

$$C_t = C_t^N + C_t^K$$

Equilibrium

- Goods market clearing:

$$Y_t = C_t^N + C_t^K + \xi_t^L X_t^L + \xi_t^H X_t^H$$

- Zero profits:

$$Y_t = W_t N_t + R_t^L K_t^L + R_t^H K_t^H$$

Capital Prices and Depreciation

- Price of aggregate capital:

$$\xi_t := \left(\frac{K_t^L}{K_t}\right)\xi_t^L + \left(\frac{K_t^H}{K_t}\right)\xi_t^H$$

- Aggregate depreciation rate:

$$\delta_t := \left(\frac{\xi_t^L K_t^L}{\xi_t K_t}\right)\delta^L + \left(\frac{\xi_t^H K_t^H}{\xi_t K_t}\right)\delta^H$$

Capital Composition and User Costs

- User costs:

$$R_t^j = \xi_{t-1}^j (1 + r_t) - \xi_t^j (1 - \delta^j)$$

- Capital composition reflects relative user costs:

$$K_t^j = \left(\frac{R_t^j}{R_t} \right)^{-\theta} K_t$$

$$R_t = \left(\left(R_t^L \right)^{1-\theta} + \left(R_t^H \right)^{1-\theta} \right)^{\frac{1}{1-\theta}}$$

Labor Share Dynamics

- Gross Labor Share:

$$s_{L,t}^{G} := \frac{W_t N_t}{Y_t} = 1 - \alpha^{\sigma} R^{1-\sigma} A_K^{\sigma-1}$$

- Net Labor Share:

$$s_{L,t}^{N} := \frac{W_t N_t}{Y_t - \delta_t \xi_t K_t} = s_{L,t}^{G} \frac{1}{1 - \psi_t}$$

- Aggregate depreciation share of gross value added:

$$\psi_t := \frac{\delta_t \xi_t K_t}{Y_t}$$

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Debate About Net and Gross Labor Shares

- In influential work, Rognlie (2014) considers a decline in r
  - Increase in patience of rich savers
  - Secular stagnation (transition to slower BGP)

- Rognlie notes in one sector model that unless $\sigma >> 1$, the net labor share will rise even when the gross labor share falls

- Concludes Piketty (2014) and Piketty and Zucman (2014) inconsistent with concerns about future growth in inequality

Debate About Net and Gross Labor Shares

Summers (2014) makes same critique:

"Piketty argues that the economic literature supports his assumption that returns diminish slowly (in technical parlance, that the elasticity of substitution is greater than 1), and so capital's share rises with capital accumulation."

"But I think he misreads the literature by conflating gross and net returns to capital ... And it is the return net of depreciation that is relevant for capital accumulation."

"I know of no study suggesting that measuring output in net terms, the elasticity of substitution is greater than 1, and I know of quite a few suggesting the contrary."

Steady State Analysis

- In steady state:

$$R^j = \xi^j \left(r + \delta^j\right) \quad \Longrightarrow \quad R = \xi \left(r + \delta\right).$$

- Substituting into the definition of depreciation share:

$$\psi = \frac{\delta \xi K}{Y} = \frac{\delta \xi}{R} \frac{RK}{Y} = \left(\frac{\delta}{r + \delta}\right)(1 - s_L^G),$$

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- Treating δ and ξ as exogenous ("two sector model"):

$$d\log\left(s_L^N\right) = \underbrace{\left(\frac{1 - s_L^N}{1 - s_L^G}\right)}_{\approx 0.75} d\log\left(s_L^G\right) + \left(\frac{s_L^N - s_L^G}{s_L^N} \frac{1 - s_L^N}{1 - s_L^G}\right) \underbrace{\left[d\log\left(\delta\right) - d\log\left(r\right)\right]}_{=0 \text{ under } A_K \text{ or } \xi \text{ shocks}}$$

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- Rognlie/Summers critique is highly shock-dependent!
- Our result: <u>New moment that suggests ξ was key shock</u>

Net vs. Gross Elasticities

- Gross Elasticity of Substitution (σ):

$$1 - \frac{1}{\sigma} = \frac{d\log\left(1 - s_L^G\right)}{d\log\left(K/Y\right)}$$

- $\sigma > 1$ or not tells us if gross labor share declines with $\frac{K}{Y}$

- Different form but standard definition ▸ Details

- To see if s_L^G and s_L^N move in same direction or not, define an equivalent object called the *Net* Elasticity of Substitution (ϵ)

Net vs. Gross Elasticities

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- Net Elasticity of Substitution (ϵ):

$$1 - \frac{1}{\epsilon} = \frac{d \log \left(1 - s_L^N\right)}{d \log \left(K/Y(1-\psi)\right)}$$

- $\epsilon > 1$ or not tells us if net labor share declines with $\frac{K}{Y(1-\psi)}$

Rognlie (2014) and Summers (2014) Argument

- Ratio of elasticities:

$$\frac{\epsilon}{\sigma} = \left[\frac{\mathrm{d}\log\left(\frac{K}{Y(1-\psi)}\right)}{\mathrm{d}\log\left(\frac{K}{Y}\right)}\right]\left[\frac{\mathrm{d}\log(R)}{\mathrm{d}\log(R-\xi\delta)}\right]$$

- Evaluate this expression under various shock combinations

Rognlie (2014) and Summers (2014) Argument

- Suppose $\mathrm{d}r \neq 0$, while $\mathrm{d}\xi = \mathrm{d}\delta = \mathrm{d}A_K = 0$:

$$\frac{\epsilon}{\sigma} = \left[\frac{1}{1-\psi}\right]\left[\frac{r}{r+\delta}\right] = \frac{1-s_L^N}{1-s_L^G} < 1 \quad \Longrightarrow \quad \epsilon < \sigma$$

- The two elasticities may be on different sides of one.

- With $\sigma = 1.25$, we get $\epsilon = 0.94 < 1$.

Our Argument

- Suppose $\mathrm{d}\xi \neq 0$, while $\mathrm{d}r = \mathrm{d}\delta = \mathrm{d}A_K = 0$:

$$\frac{\epsilon}{\sigma} = \left[\frac{1}{1-\psi}\left(1 - \frac{\psi}{\sigma}\right)\right]\left[1\right] \quad \Longrightarrow \quad (\epsilon - 1) = \frac{s_L^N}{s_L^G}(\sigma - 1)$$

- The two elasticities must be on the same side of one.

- With $\sigma = 1.25$, we get $\epsilon = 1.29 > 1$.

Intuition and Implications

$$(1)\ R = \xi(r+\delta) \qquad (2)\ s_L^g = s_L^N(1-\psi) \qquad (3)\ \psi = \delta\xi\frac{K}{Y}$$

- A given decline in R causes a given increase in s_L^G and K/Y, regardless of whether caused by ξ or r.
- But only ξ mutes the impact of rise in K/Y on ψ, which is required to match data. Argues for importance of ξ over r.
- This logic should hold for any component of user-cost (e.g. τ)

Back to Three Sectors

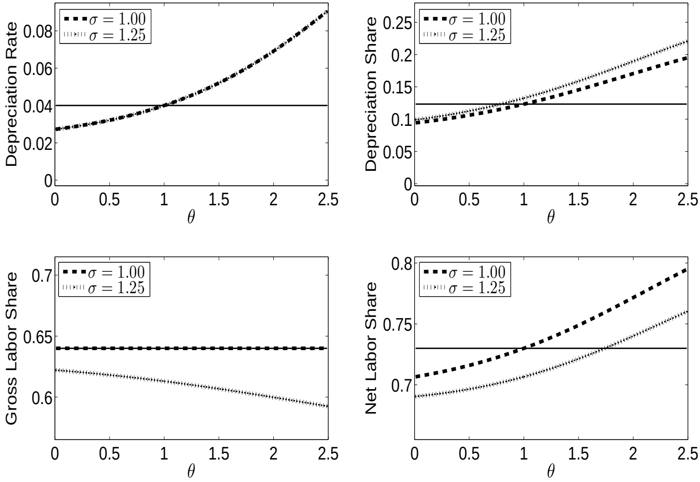
- In "three sector" model, shocks to ξ^H or β, for example, simultaneously impact "two sector" shocks, including δ and ξ.

- To analyze this, we consider two experiments:
  1. ξ^H declines by 67%
  2. β increases by 0.05

- Initial values: $\delta = 0.05$, $R = 0.10$, $s_L^G = 0.65$, and $s_L^G = 0.73$, with $\delta^L = 0.03$ and $\delta^H = 0.20$.

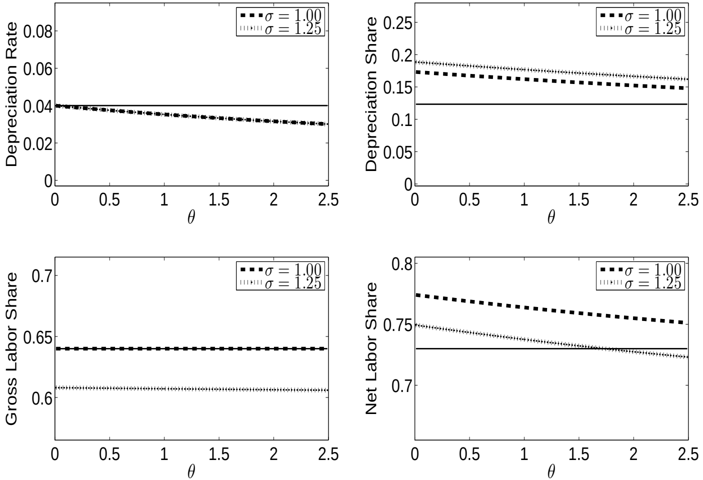
- As we vary σ and θ, we change β, ξ^L, ξ^H, and A_K.

Decrease in Price of High Depreciation Capital (ξ^H)



$$d\delta = (1-\theta)(r+\delta)\left(\left(\chi^L + \zeta^L\right) d\ln(\xi^L) + \left(\chi^H + \zeta^H\right) d\ln(\xi^H)\right) + \theta\left(1 + \frac{(\zeta^L)^2}{\chi^L} + \frac{(\zeta^H)^2}{\chi^H}\right) dr$$

Increase in Discount Rate (β)



$$d\delta = (1-\theta)(r+\delta)\left(\left(\chi^L+\zeta^L\right)d\ln(\xi^L)+\left(\chi^H+\zeta^H\right)d\ln(\xi^H)\right)+\theta\left(1+\frac{(\zeta^L)^2}{\chi^L}+\frac{(\zeta^H)^2}{\chi^H}\right)dr$$

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Gross and Net Labor Shares and Inequality

- Steady state consumption ratio:

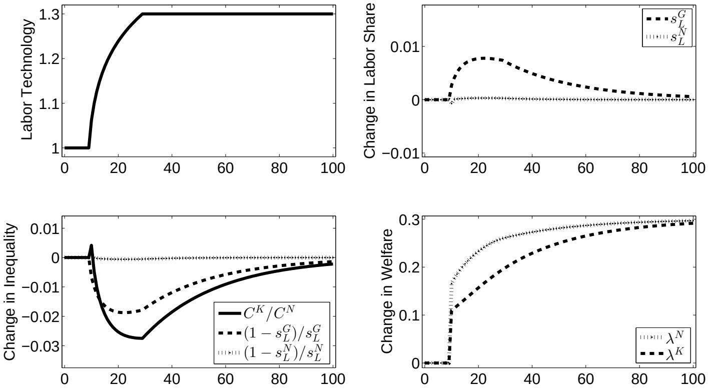
$$\frac{C^K}{C^N} = \frac{(R - \delta\xi) K}{WN} = \frac{1 - s_L^N}{s_L^N}.$$

- Since consumption is constant in steady-state, this is welfare-relevant notion of inequalty.

- In this sense, *net* labor share is perfectly informative about inequality in steady state.

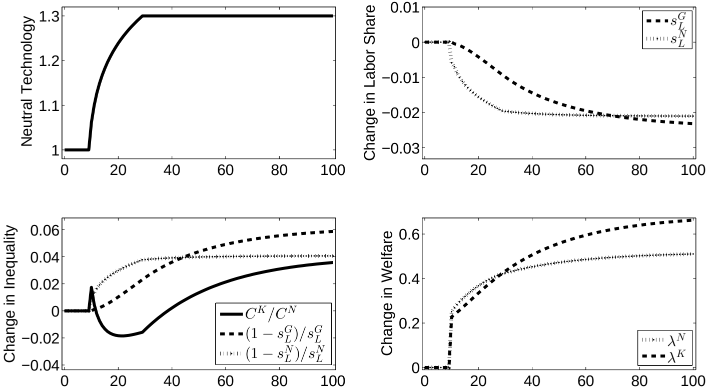
- The link, however, is not obvious over the transition.

Increase in A_N



$$\left(\frac{1}{1-\beta}\right) U\left(C^i(1+\lambda_t^i)\right) = U\left(C_t^i\right) + \beta V_{t+1}.$$

Increase in Factor-Neutral Technology $A_K = A_N$



$$\left(\frac{1}{1-\beta}\right) U\left(C^i(1+\lambda_t^i)\right) = U\left(C_t^i\right) + \beta V_{t+1}.$$

Summary: Gross vs. Net Labor Shares During Transition

Shock	Inequality Measure	Change From Initial Steady State $t=10$	$t=20$	$t=50$	$t\to\infty$
$\uparrow A_N$	$(1+\lambda_t^K)/(1+\lambda_t^N)$	-0.062	-0.052	-0.018	0.000
	$(1-s_t^N)/s_t^N$	-0.002	-0.001	0.000	0.000
	$(1-s_t^G)/s_t^G$	-0.033	-0.032	-0.011	0.000
$\uparrow A_N = A_K$	$(1+\lambda_t^K)/(1+\lambda_t^N)$	-0.026	0.002	0.072	0.110
	$(1-s_t^N)/s_t^N$	0.078	0.102	0.109	0.110
	$(1-s_t^G)/s_t^G$	0.016	0.041	0.087	0.110
$\uparrow \beta$	$(1+\lambda_t^K)/(1+\lambda_t^N)$	-0.176	-0.145	-0.087	-0.033
	$(1-s_t^N)/s_t^N$	-0.001	-0.005	-0.016	-0.033
	$(1-s_t^G)/s_t^G$	0.030	0.058	0.107	0.151
$\downarrow \xi^H$	$(1+\lambda_t^K)/(1+\lambda_t^N)$	0.013	0.033	0.082	0.109
	$(1-s_t^N)/s_t^N$	0.105	0.119	0.108	0.109
	$(1-s_t^G)/s_t^G$	0.045	0.076	0.111	0.128

Conclusions and Next Steps

- Global decline in gross and net labor shares. Some heterogeneity, but comparable declines in both measures.
- Similar movement suggests salience of ξ shock, as in KN1.
- In transition, unlike steady-state, not clear which measure more informative about inequality
- Inequality here only "between" inequality. In work in progress, model where "between" and "within" jointly determined:

$$CV\left(y\right) = s_L \rho\left(y^L, y\right) CV\left(y^L\right) + (1 - s_L)\rho\left(y^K, y\right) CV\left(y^K\right)$$