

The Innovation Engel Curve

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Income inequality and consumer demand



Walter Reuther, President of the
United Auto Workers (1946–1970)

“I went through this Ford engine plant about three years ago, when they first opened it. There are acres and acres of machines, and here and there you will find a worker standing at a master switchboard, just watching, green and yellow lights blinking off and on...

One of the management people, with a slightly gleeful tone in his voice said to me, ‘How are you going to collect union dues from all these machines?’

And I replied, ‘You know, that is not what’s bothering me. **I’m troubled by the problem of how to sell automobiles to these machines.**”

— Walter Reuther, *Selected Papers*, 1961.

Motivation

- Technology likely to both increase productivity and income inequality
- A key question is who receives income and what goods they demand
- Growth requires demand for innovation-intensive goods
- If inequality shifts demand away from those goods, growth can slow

Main results

- We study the effect of inequality on innovation content of consumption
- We document new facts based on large-scale transaction data for US:
 - Firm side: Firms selling to the top of income distribution have lower innovation intensity
 - HH side: Households in top 1% of income consume a bundle with lower innovation intensity
- We build a model with:
 - choice of mass-market goods vs. exclusive goods and services
 - satiation with respect to mass-market goods
 - innovation through new varieties of mass-market goods
- We find that rising inequality reduces demand for innovation and slows growth
 - Quant. exercise: rise in inequality accounts for 40% of growth slowdown 1980s vs 2010s.

Related literature

- Structural change
 - For example, Kongsamut et al. (2001), Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008), Duarte and Restuccia (2010), and Buera and Kaboski (2012)
- Engel curves
 - Engel (1857), Pollak (1971), Deaton and Muellbauer (1980), Bils and Klenow (2001), and Comin, Lashkari, and Mestieri (2021)
- Models with satiation
 - Ramsey (1928) and Samuelson and Solow (1956)
 - Laitner (2000), Gollin, Parente, and Rogerson (2002, 2007), and Foellmi and Zweimüller (2008)

Related literature

- Inequality and growth
 - Kuznets (1955), Deininger and Squire (1996), Galor and Zeira (1993), Aghion et al. (1999), and Piketty and Saez (2003)
- Link between mass production and mass consumption
 - Nicholas Kaldor (1966), Michel Aglietta (1976), Robert Gordon (2016)
- Hierarchical and social preferences
 - Thorstein Veblen (1899), *The Theory of the Leisure Class*
 - Abraham Maslow (1943), *A Theory of Human Motivation*
 - from functional and monetary value to psychological value

Plan of the Talk

1. Introduction

2. Data

- Large-scale transaction data: income, expenditure, firms, patents
- Pre-processing and basic moments
- A first luxury Engel curve
- Luxury classification at scale
- The Innovation Engel Curve

3. Model

4. Quantification

5. Conclusion

Dataset

- Proprietary U.S. household transaction data from Fintech firm
- From 2.1 billion transactions (2015–19), build household measures of:
 - total income
 - total expenditure
 - expenditure shares across firms
- Match firms (by name) to other sources of firm covariates:
 - Compustat for subset of firms
 - Universe of US patents

Lets us ask: how does innovation content of consumption vary across the income distribution?

Sample construction

Building a HH income-expenditure panel

- Restrict spending to identifiable consumption categories
- Require sufficient account activity; positive income and expenditure flows
- Remove duplicates and extreme outliers
- Restrict to U.S. dollar-denominated accounts
- Exclude users with many linked accounts (likely businesses)

Building and matching firm identifiers

- DBSCAN text clustering of merchant name strings into ~ 1 M internal firm identifiers
- Transformer-based fuzzy matching (LinkTransformer) to Compustat and PatentsView with multi-stage manual validation

\Rightarrow *604,499 US Households & 1,155,444 US firms*

Income and expenditure

Income group	HHs	Avg. yearly income	Avg. yearly expenditure
<i>CEX (Reference)</i>	—	\$75,870	\$59,522
Overall mean	604,499	\$84,322	\$72,642
0–25%	151,125	\$27,597	\$60,631
25–50%	151,124	\$59,088	\$57,017
50–75%	151,125	\$86,487	\$67,425
75–90%	90,675	\$122,432	\$82,360
90–95%	30,225	\$162,746	\$101,184
95–99%	24,180	\$226,655	\$134,547
99–100%	6,045	\$546,092	\$357,890

Note: Most comprehensive expenditure measure: includes cash withdrawals, rent and payments via fintechs.

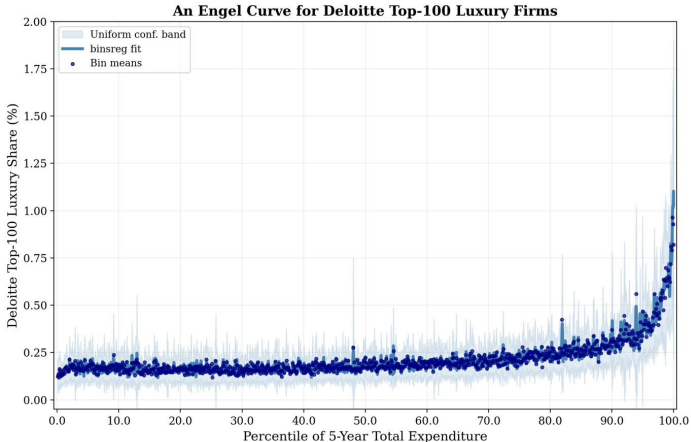
- Total income $Y_h \equiv \sum_t \text{Income}_{h,t}$, total expenditure $E_h \equiv \sum_t \text{Expenditure}_{h,t}$
- Aggregating over 2015–19 to construct Y_h and E_h :
 - reduces noise
 - smooths durables and transitory fluctuations
- Average yearly income and expenditure 10-20% larger than CEX

Expenditure inequality

Income group	Share of aggregate expenditure
Bottom 50%	40.5%
Top 25%	36.3%
Top 10%	19.3%
Top 5%	12.3%
Top 1%	4.9%
Top 0.1%	1.9%

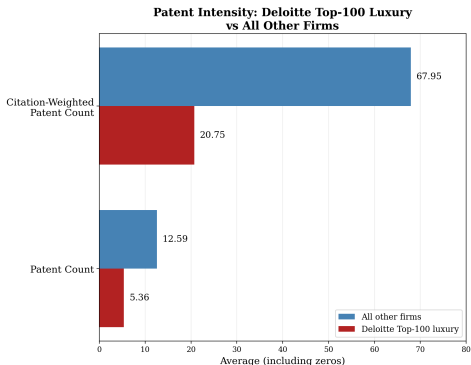
- Data slightly undershoots expenditure inequality vs. [BLS](#) prototype distributional accounts:
 - BLS: top-1% share = 7.1%, top-5% share = 17% (same period)

A first luxury Engel curve



Flat $\sim 0.15\%$ across most of the distribution; sharp takeoff above P95, reaching $\sim 1\%$ at the top.

Patent intensity of top-100 luxury firms



- Now match top-100 firms+ name variations to universe of US patents (2000–2014)
- Top-100 luxury vs All other firms:
 - Patent count: 5.4 vs 12.6
 - Citation-weighted: 20.9 vs 68.0

⇒ *Top-100 luxury firms serving the top of expenditure distribution are less innovation intensive.*

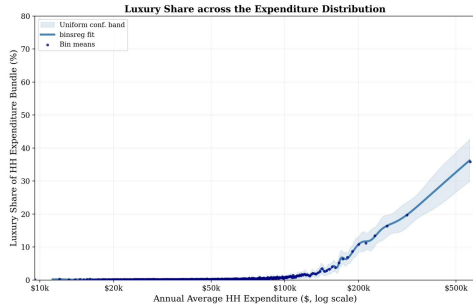
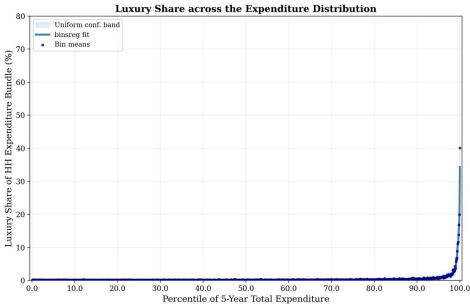
Scaling up: a luxury firm classifier

We now move from a curated list to an **automated, firm-side classifier**.

- **Definition.** Firm f is *luxury* if $> 50\%$ of its 5-year mapped sales goes to households in the top 1% of the expenditure distribution.
 - V. similar results for other thresholds (e.g. top 5% or top 10%); not reported today
- **Coverage:**
 - 33,762 firms classified luxury (2.92% of universe)
 - Account for 5.9% of sales
 - About half of the top-100 Deloitte luxury firms have at least one fintech ID classified as luxury (rises to $>80\%$ if top 10% criteria)

⇒ *Broader luxury coverage, fully data-driven.*

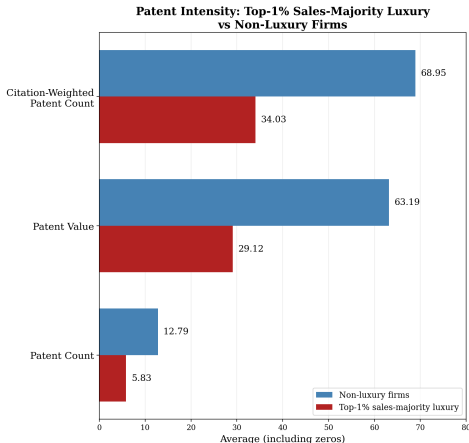
Top-1% luxury Engel curve



⇒ Top 1% expenditure share on luxuries: 30%; Bottom 99% <1%.

Note: Engel curve not (log) linear.

Luxury firms are less patent intensive



- Match the luxury (33,762 firms) names to the universe of US patents (2000–2014)
- Top-1% luxury vs All other firms:
 - Patent count: **5.8** vs 12.8
 - Citation-weighted: **34.0** vs 68.9
 - Patent value: **29.1** vs 63.2

⇒ *The luxury–innovation gap survives the scale-up.*

Innovation content of HH expenditure bundles

We now inspect relation from the household side.

Let e_{hf} be expenditure of household h at firm f . Define the household-specific expenditure share on firm f :

$$\omega_{hf} = \frac{e_{hf}}{\sum_{f'} e_{hf'}}$$

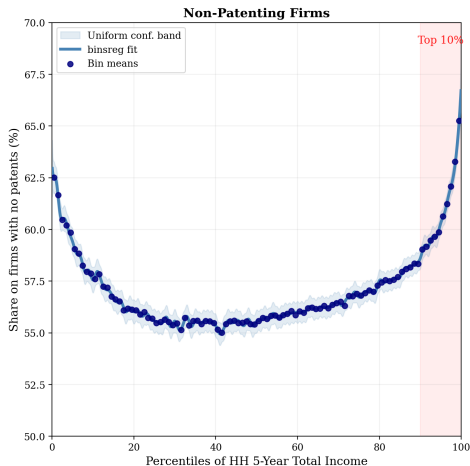
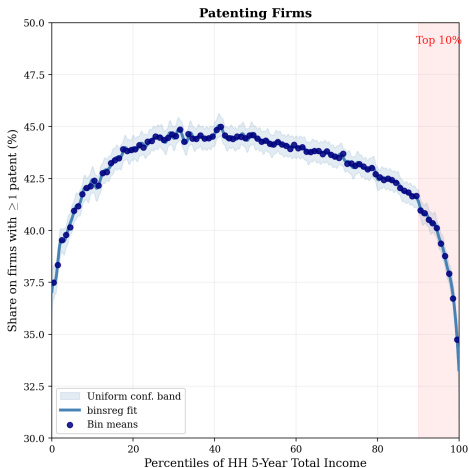
For an innovation measure M_f at the firm level, the **innovation intensity of h 's consumption bundle** is:

$$PV_h = \sum_f \omega_{hf} M_f$$

Four candidate innovation measures M_f :

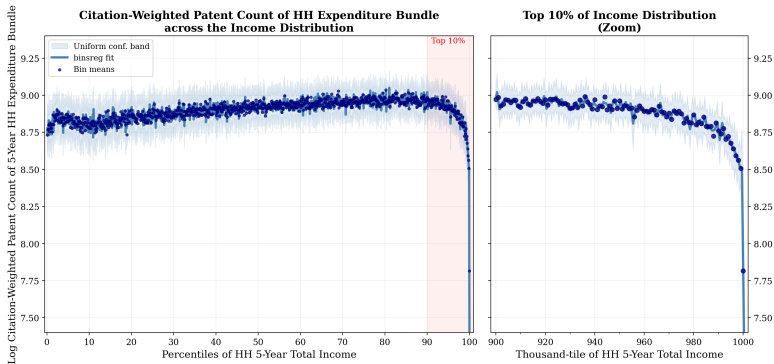
- Patent count
- Citation-weighted patent count
- Patent value (Kogan et al. 2017; Compustat firms only)
- Imputed patent value (via citation \rightarrow value regression; extends to non-listed firms)

Innovation Engel Curve – patent counts



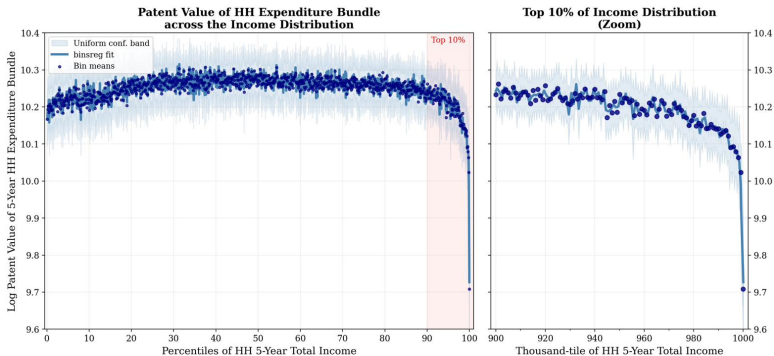
Top 10% households shift expenditure away from patenting firms (45% \rightarrow 35%) and toward non-patenting firms (55% \rightarrow 65%) – a 10 pp reallocation away from innovation.

Innovation Engel Curve – citation-weighted patent count



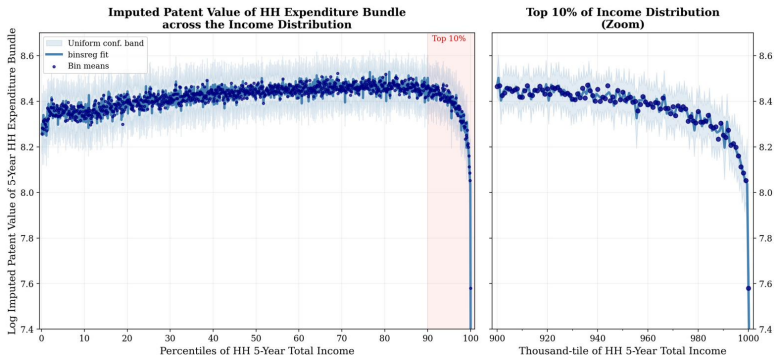
Top 1% income households' expenditure bundle is 35% less innovation-intensive when measured by citation-weighted patent counts.

Innovation Engel Curve – patent value



Top 1% income households' expenditure bundle is 22% less innovation-intensive when measured by patent value (publicly listed firms only).

Innovation Engel Curve – imputed patent value



- Imputation: regress log patent value on log citation-weighted count (and its square) on Compustat-matched firms; apply fitted relationship to all firms.

Top 1% income households' expenditure bundle is 30% less innovation-intensive when measured by imputed patent value.

Innovation Engel Curve recap

- **Firm side:** firms that disproportionately sell to the top of the income distribution are less innovation-intensive
- **Household side:** relative to the bottom 99%, the top 1% tilts its expenditure bundle toward less innovation-intensive firms
 - higher share spent on firms with no patents
 - higher share on firms with low citation-weighted patent counts
 - higher share on firms with low (imputed) patent value

⇒ Rising inequality will shift demand away from innovation-intensive goods and services

Plan of the Talk

1. Introduction

2. Data

3. Model

- Preferences: Non-homotheticity and Satiation
- Production: Mass-Market Goods vs. Exclusive Goods
- Pricing, Profits and Inequality
- Growth and Inequality: Innovation, BGP, Regimes

4. Quantification

5. Conclusion

Utility

Momentary utility of type ϵ household:

$$u_t(\epsilon) = \gamma \log \left(\left[\int_0^n \min(c_{i,t}(\epsilon), \bar{c})^{1/\nu} di \right]^\nu \right) + (1 - \gamma) \log Q_t(\epsilon)$$

Preferences over 2 goods: **Mass-Market** vs. **Exclusive Goods**.

- Outer log gives balanced growth path compatibility
- **Mass-Market bundle**: CES over n_t differentiated varieties $c_{i,t}(\epsilon)$
- **Exclusive Q**: no satiation, absorbs income beyond the bliss point
- \bar{c} : **bliss point — per-good mass-market consumption satiation**
 - Below \bar{c} : locally homothetic — standard Dixit–Stiglitz
 - Above \bar{c} : non-homothetic kicks in — extra income flows to exclusive

All that follows is a consequence of this kink!

HH Problem

Households differ in (permanent) productivity ϵ , distributed $\Gamma(\epsilon)$.

Utility:

$$U(\epsilon) = \int_0^{\infty} e^{-\rho t} u_t(\epsilon) dt$$

Budget constraint:

$$p_s^n \dot{s}_n(\epsilon) + p_s^q \dot{s}_q(\epsilon) + \dot{b}(\epsilon) + \int_0^n p_{c,i} c_i(\epsilon) di + P_Q Q(\epsilon) = s_n(\epsilon) \pi_n + s_q(\epsilon) \pi_q + rb(\epsilon) + W\epsilon$$

- Labor income: $W\epsilon$
- Capital income from equities and bonds: $s_n(\epsilon)\pi_n + s_q(\epsilon)\pi_q + rb(\epsilon)$
- We assume that assets are initially distributed in proportion to: ϵ
- Spending on mass-market goods: $\int_0^n p_{c,i} c_i(\epsilon) di$
- Spending on exclusive goods: $P_Q Q(\epsilon)$

HH First Order Conditions

Below bliss \bar{c} : standard CES interior solution.

$$\gamma \frac{1}{\int_0^n c_i^{1/\nu} di} c_i^{1/\nu-1} = \lambda p_{c,i}$$

In symmetric eqm ($c_i = c$) \Rightarrow constant expenditure shares at γ .

At bliss \bar{c} : extra unit delivers zero utility.

$$c_i = \bar{c}$$

Exclusive consumption: always interior.

$$(1 - \gamma) \frac{1}{Q} = \lambda P_Q$$

Above bliss, extra income redirected into Q.

Productivity threshold

Optimal household expenditure is proportional to ϵ

$$X_t(\epsilon) = \underbrace{s_n \pi_n + s_q \pi_q + rb + W_t \epsilon}_{\text{income}} - \underbrace{(p_s^n \dot{s}_n + p_s^q \dot{s}_q + \dot{b})}_{\text{investment}} = \Xi_t \epsilon$$

Labor income is $W\epsilon$; assets proportional to ϵ ; on BGP net savings grow in proportion to initial holdings — so also linear in ϵ .

⇒ There exists a productivity cutoff ϵ^* such that:

- $\epsilon < \epsilon^*$: bliss point does not bind
- $\epsilon \geq \epsilon^*$: consumption is at \bar{c} for all mass-market varieties

$$\Xi_t \epsilon^* = \frac{n_t p_c \bar{c}}{\gamma} \quad \Rightarrow \quad \epsilon^* = \frac{n_t p_c \bar{c}}{\gamma \Xi_t}$$

[On BGP, n_t and Ξ_t grow at the same rate ⇒ ϵ^* is constant on the BGP.]

Optimal consumption

In symmetric eqm, consumption of each differentiated good:

$$c_t(\epsilon) = \begin{cases} \bar{c} \frac{\epsilon}{\epsilon^*}, & \epsilon \leq \epsilon^* \\ \bar{c}, & \epsilon \geq \epsilon^* \end{cases}$$

- HHs below cutoff productivity:
 - buy same mix of varieties with quantity linearly increasing in income
- HHs above cutoff:
 - each mass-market good is fixed at bliss, extra income flows into Q

Production structure: exclusive goods

Monopolist-‘artisan’ i produces exclusive good with **labor-only** technology

$$x_{q,i} = L_{q,i}$$

Sets price of its differentiated good as markup over marginal cost

$$p_{q,i} = \frac{W}{1 - \beta}$$

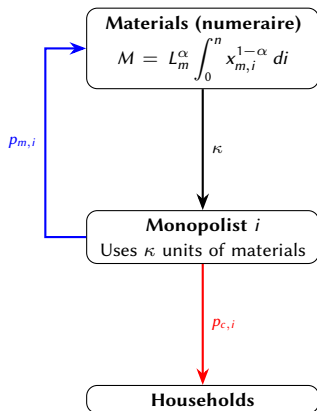
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Competitive firm aggregates **mass 1** of differentiated exclusive goods

$$Q = \left(\int_0^1 x_{q,i}^{1-\beta} di \right)^{\frac{1}{1-\beta}}$$

*2 assumptions: (i) exclusivity produced with non-reproducible factor
(ii) measure of artisans is fixed (no growth via new varieties of exclusive goods).*

Production structure: mass-market goods



- Materials' producers are competitive producers (numeraire)
 - Inputs: mass-market varieties and labor
- Monopolistic producers use materials to produce i variety :
 - Standard markup charged to material production in roundabout step ($p_{m,i} = \kappa / (1 - \alpha)$)
 - Markup to households depends on \bar{c} binding (next slide)
- *Love-of-variety*: more varieties \rightarrow materials production more efficient \rightarrow cheaper materials \rightarrow more variety creation \rightarrow growth

GE preview: More inequality \rightarrow more HHs above ϵ^* \rightarrow more demand for Q \rightarrow labor reallocates away from materials \rightarrow wages bid up \rightarrow depresses profits of downstream monopolist.

Monopolistic pricing when \bar{c} is binding

$$\max \pi_{c,i} = (p_{c,i} - \kappa) \left[\underbrace{\int_{\epsilon_{\min}}^{\epsilon^*} \Gamma'(\epsilon) c_i(\epsilon) d\epsilon}_{\text{elastic demand}} + \underbrace{(1 - \Gamma(\epsilon^*)) \bar{c}}_{\text{locally inelastic demand}} \right]$$

$$p_{c,i} = \nu \kappa \frac{1}{1 - (\nu - 1) \frac{(1 - \Gamma(\epsilon^*)) \bar{c}}{\frac{\bar{c}}{\epsilon^*} \int_{\epsilon_{\min}}^{\epsilon^*} \Gamma'(\epsilon) \epsilon d\epsilon}}$$

Or

$$p_{c,i} = \nu \kappa \frac{1}{1 - \underbrace{(\nu - 1)}_{>0} \frac{\text{inelastic demand}}{\text{elastic demand}}}$$

*Optimal price: standard $\nu \kappa$ markup amplified by ratio of inelastic to elastic demand.
More households at the bliss point \Rightarrow higher ratio \Rightarrow higher markup.*

Inequality and profits

When inequality increases \rightarrow profits from innovation in mass-market fall.

Special Analytic Case

Exclusive sector is competitive ($\beta = 0$).

Mean-preserving spread: $\Upsilon_H \uparrow$, $\Upsilon_L \downarrow$,
holding total efficiency units L fixed.

Proposition: if markup $< 2\nu - 1$,

$$\frac{d \text{markup}}{d\Upsilon_H} > 0 \quad \text{but} \quad \frac{d\pi_c}{d\Upsilon_H} < 0$$

Intuition

When some households are constrained at \bar{c} :

- quantity sold to rich households no longer rises with income
- demand becomes less elastic
- markups may rise
- but total quantities sold fall

The key result:

- decline in demand dominates if markup not too high
- \rightarrow profits from innovation fall

Innovation

- Intermediate goods producers can create a new variety by investing $1/\Psi$ units of materials
- Law of motion for number of varieties

$$\dot{n} = \Psi m.$$

- Free entry

$$\frac{1}{\Psi} = \frac{\pi_c + \pi_m}{r}.$$

*Inequality depresses π_c while π_m is unaffected
⇒ total profits fall ⇒ innovation slows.*

Since $r = \rho + g$ on the BGP, lower profits imply lower r and lower g .

Balanced growth path

We study a symmetric balanced growth path.

Main equilibrium ingredients:

- ▶ labor market clearing
- ▶ materials market clearing
- free entry in innovation
- household optimality
- cutoff ϵ^*

Inequality and growth: recap

- Higher inequality raises the mass of households above the bliss point
- Their spending shifts from mass-market goods to exclusive while
- Demand for mass-market goods now more inelastic: their markup \uparrow
- Aggregate demand for innovation-intensive mass-market goods falls
- Profits in the innovation-producing sector fall
 - GE-effect reinforces: $Q\text{-demand} \uparrow \rightarrow L_q \uparrow \rightarrow \text{wages} \uparrow \rightarrow \text{materials costs} \uparrow \rightarrow \pi_c \downarrow$
- Entry of new varieties falls
- Growth and the real interest rate decline

Plan of the Talk

1. Introduction
2. Data
3. Model
- 4. Quantification**
 - Calibration
 - Experiments
5. Conclusion

Experiment: change in the skill distribution

We study a technological revolution that:

- raises the productivity of households above ϵ^*
- lowers the productivity of households below ϵ^*
- keeps aggregate labor supply fixed

Interpretation:

- new technology complements skills of a small elite and substitutes for skills of the rest

Calibration

- Ability follows a truncated Pareto distribution

$$\Gamma'(\epsilon) = \frac{\eta \epsilon_{\min}^{\eta} \epsilon^{-(\eta+1)}}{1 - (\epsilon_{\min}/\epsilon_{\max})^{\eta}}, \quad \epsilon \in [\epsilon_{\min}, \epsilon_{\max}].$$

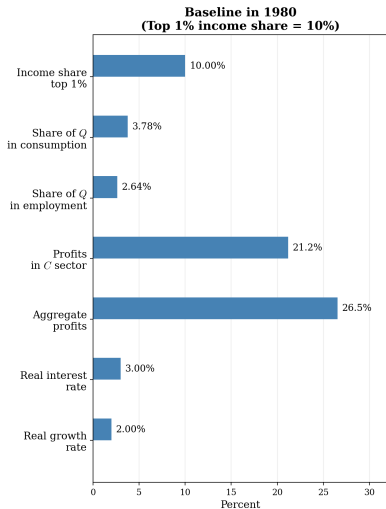
- Choose η and ϵ_{\max} to match two moments
 - income share of the top 1% (10% in late 1970s)
 - log ratio of patent intensity between the top 1% and the rest is 30% (our estimate) when the top income share is 20% (as in the late 2010s)
- Top income share target

$$\text{share of top 1\%} = \frac{(1-p)\bar{\epsilon}_H}{p\bar{\epsilon}_L + (1-p)\bar{\epsilon}_H} = 0.1, \quad p = 0.99,$$

where $\bar{\epsilon}_L \equiv \mathbb{E}[\epsilon \mid \epsilon < \epsilon^*]$, $\bar{\epsilon}_H \equiv \mathbb{E}[\epsilon \mid \epsilon \geq \epsilon^*]$.

- Given (η, ϵ_{\max}) and the top-1% cutoff ϵ^* , the bliss point \bar{c} is pinned down by the cutoff condition

1980 US Calibration



- Technology

- $\alpha = 0.92$ matches aggregate labor share 0.7

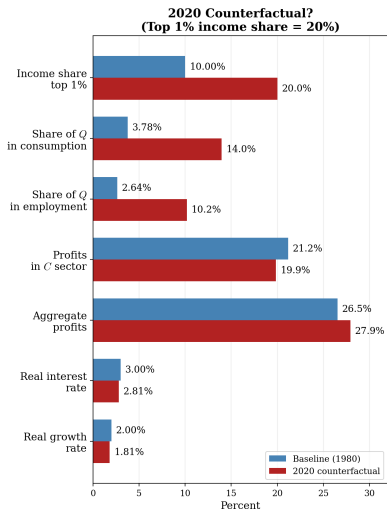
- Benchmark targets

- Growth rate: $g = 2\%$
- Time preference: $\rho = 1\%$
- Implied interest rate: $r = g + \rho = 3\%$
- C -sector markup: 1.4
- Q -sector markup: 1.52

- Expenditure share

- $\gamma = 0.9959$ (Avg. consumption of bottom 99% on Non-Luxury (homothetic HHs))
- Results robust to alternative γ
- $\frac{\text{Patent intensity top 1\%}}{\text{Patent intensity bottom 99\%}} = 0.7 \rightarrow$ share of top 1% on Q of 0.3

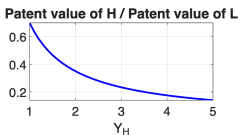
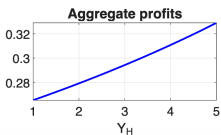
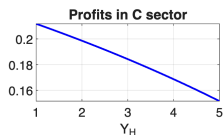
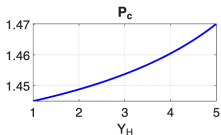
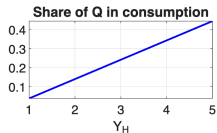
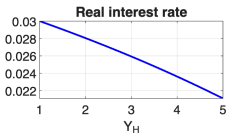
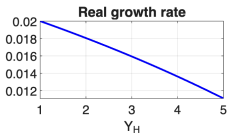
US 2020 Income Distribution



As inequality rises:

- expenditure and employment shift toward exclusive luxury
- profits in the goods sector decline
- aggregate profits rise
- the real interest rate declines
- **growth declines**
 - *US average real growth rate pc*
 - *1980s — 2.13% vs. 2010s — 1.65%*
 - *through the lens of the model, the inequality–innovation link accounts for 40% of this decline*

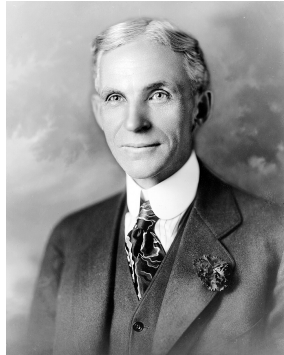
Possible futures



AI and the future

- If gains from automation accrue to a small number of households, where will demand for mass-produced goods supplied by innovation-driven firms come from?
- Central role of mass consumption in providing the scale of demand necessary to sustain investment and growth, captured by the quote attributed to Henry Ford:

“Sell to the masses, live with the classes, sell to the classes, live with the masses.”



Henry Ford, 1863–1947

Labor market clearing

Labor is used in materials and quality:

$$L = L_m + L_q,$$

where

$$L = \int_{\epsilon_{\min}}^{\epsilon_{\max}} \epsilon \Gamma'(\epsilon) d\epsilon.$$

- Rising inequality shifts expenditure toward quality
- This shift reallocates labor toward the quality sector

◀ back to BGP

Materials market clearing

- Materials are used for:
 - production of consumption goods
 - production of intermediate goods for materials
 - creation of new varieties
- Market clearing:

$$L_m^\alpha n x_m^{1-\alpha} = \kappa n (c + x_m) + n \frac{g}{\Psi}$$

◀ back to BGP