The Innovation Engel Curve

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July 2027

Income inequality and consumer demand



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

Motivation

- Artificial intelligence is likely to increase both productivity and income inequality
- Key question: who receives income and what goods do 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. luxury goods and services
  - satiation with respect to mass-market goods
  - innovation through new varieties of mass-market goods
- Higher inequality reduces demand for innovation and slows growth

Related literature

- Classical debates about luxury
  - David Hume (1752) *Of the Refinement in Arts* and Adam Smith (1759) *A Theory of Moral Sentiments.*
- 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 $\sim$1M 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
CEX (Reference)	—	*$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)

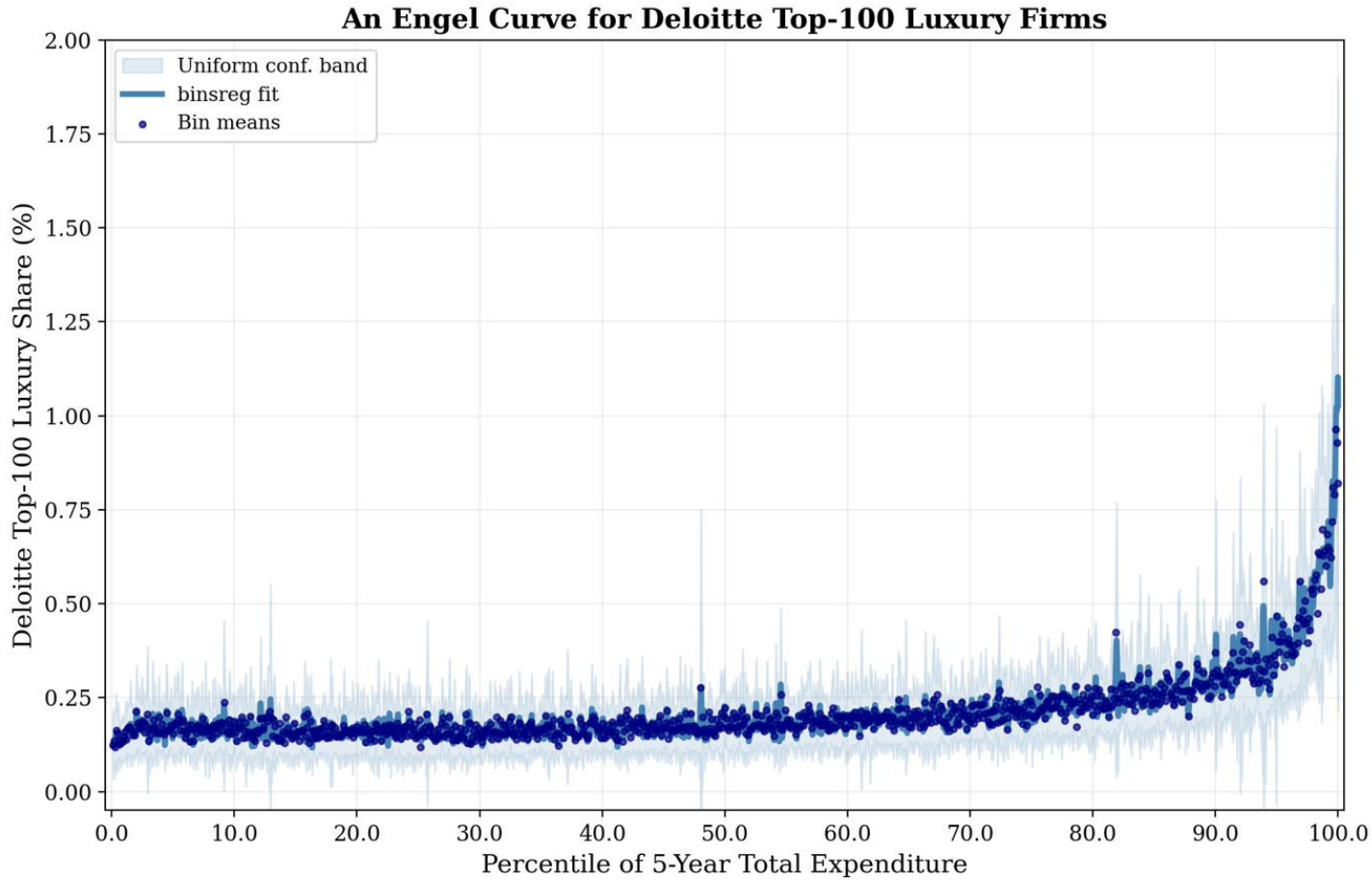
A first look at exclusivity

Global Powers of Luxury Goods Top 100, FY2017

FY2017 Luxury goods sales ranking	Change in ranking	Name of company	Country of origin	Selection of luxury brands	FY2017 Luxury goods sales (US$m)	FY201 Tot revenu (US$n
1	0	LVMH Moët Hennessy-Louis Vuitton SE	France	Louis Vuitton, Christian Dior, Fendi, Bvlgari, Loro Piana, Emilio Pucci, Acqua di Parma, Loewe, Marc Jacobs, TAG Heuer, Benefit Cosmetics	27,995	48,05
2	0	The Estée Lauder Companies Inc.	US	Estée Lauder, Bobbi Brown, La Mer, Jo Malone London, Aveda; Licensed beauty & fragrance brands inc Tom Ford Beauty	13,683	13,68
3	0	Compagnie Financière Richemont SA	Switzerland	Cartier, Van Cleef & Arpels, Montblanc, Jaeger-LeCoultre, Vacheron Constantin, IWC, Piaget, Chloé, Officine Panerai, YNAP	12,819	12,81
4	1	Kering SA	France	Gucci, Bottega Veneta, Saint Laurent, Balenciaga, Brioni, Pomellato, Girard-Perregaux, Ulysse Nardin	12,168	17,44
5	-1	Luxottica Group SpA	Italy	Ray-Ban, Oakley, Vogue Eyewear, Persol, Oliver Peoples; Licensed eyewear brands	10,322	10,32
6	New	Chanel Limited	UK	Chanel	9,623	9,62
7	-1	L'Oréal Luxe	France	Lancôme, Kiehl's, Urban Decay, Biotherm, IT Cosmetics; Licensed brands	9,549 e	9,54
8	-1	The Swatch Group Ltd.	Switzerland	Omega, Longines, Breguet, Harry Winston, Rado, Blancpain; Licensed watch brands	7,819	8,08
9	1	Chow Tai Fook Jewellery Group Limited 周大福珠宝集团有限公司	Hong Kong	Chow Tai Fook, CHOW TAI FOOK T MARK, Hearts on Fire, Monologue, Soinlove	7,575	7,57
10	-1	PVH Corp.	US	Calvin Klein, Tommy Hilfiger	7,355	8,91
11	0	Hermès International SCA	France	Hermès, John Lobb	6,255	6,25
12	-4	Ralph Lauren Corporation	US	Ralph Lauren, Polo Ralph Lauren, Lauren Ralph Lauren, Chaps, Club Monaco	6,182	6,18
13	2	Tapestry, Inc. (formerly Coach, Inc.)	US	Coach, Kate Spade, Stuart Weitzman	5,880	5,88
14	-2	Rolex SA	Switzerland	Rolex, Tudor	5,686 e	5,68
15	-2	Lao Feng Xiang Co., Ltd 老凤祥股份有限公司	China	Lao Feng Xiang	5,346	5,88
16	1	Shiseido Prestige & Fragrance	Japan	SHISEIDO, clé de peau BEAUTÉ, Benefique, bareMinerals, NARS, IPSA, Laura Mercier; Licensed fragrance brands	4,748 e	4,74
17	-3	Michael Kors Holdings Limited (now Capri Holdings Limited)	UK	Michael Kors, MICHAEL Michael Kors, Jimmy Choo	4,719	4,71
18	-2	Tiffany & Co.	US	Tiffany & Co., Tiffany	4,170	4,17

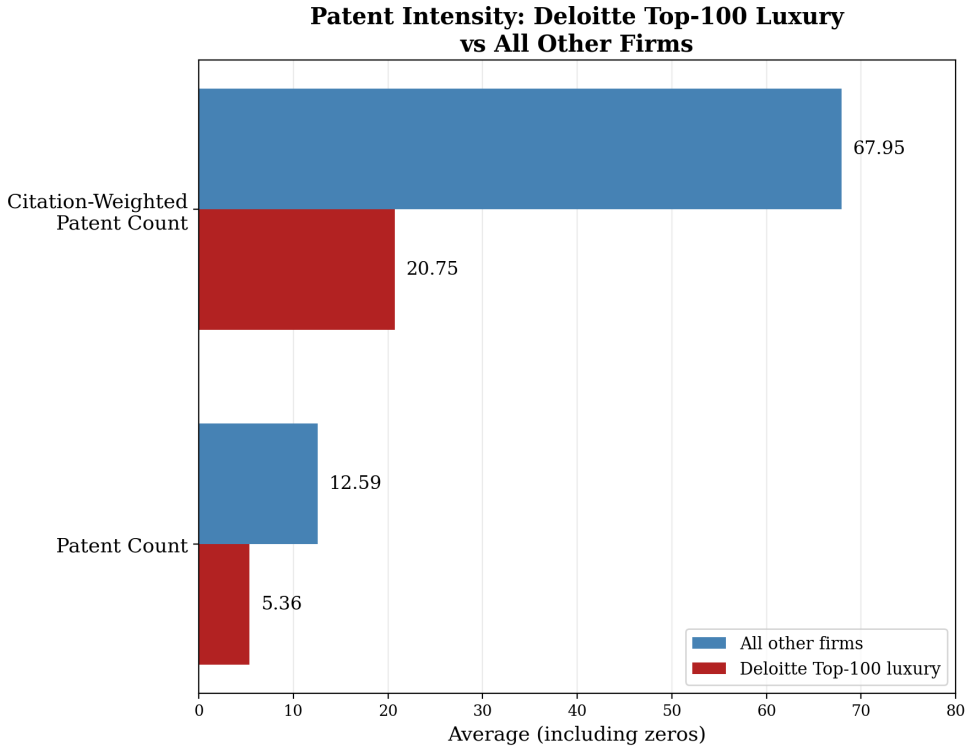
- Starting point: Deloitte *Global Powers of Luxury Goods* (FY2017) top-100 firm/brand list
- LLM-assisted matching of top-100 to our internal firm IDs
  - we match both parent firms and respective brand names
- Merge with household expenditure data to calculate:
  - 5-year HH expenditure share on the Deloitte top-100 bundle, across the expenditure distribution

A first luxury Engel curve



Flat ∼0.15% across most of the distribution; sharp takeoff above P95, reaching ∼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.

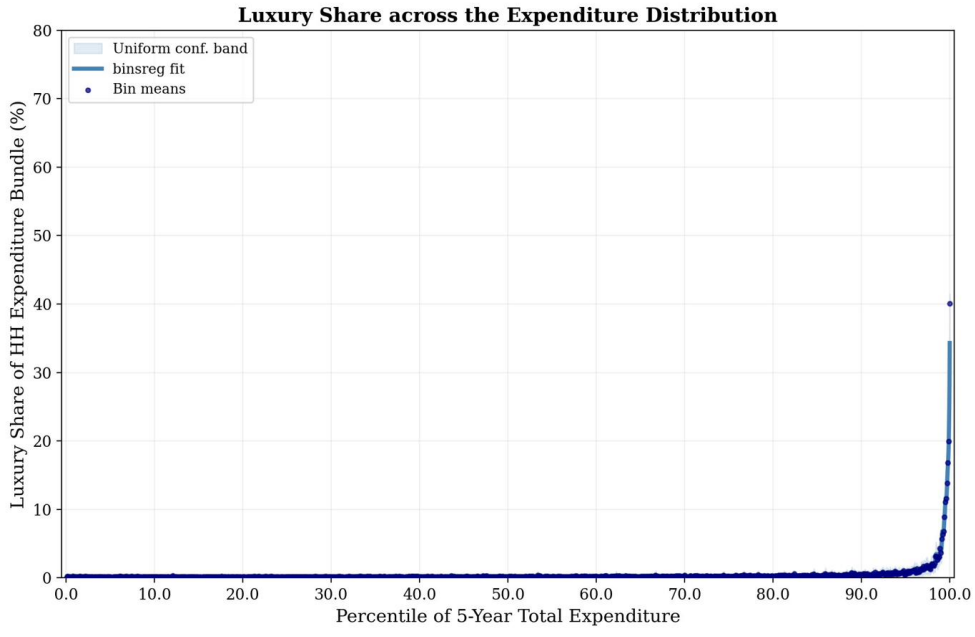
Scaling up: a luxury firm classifier

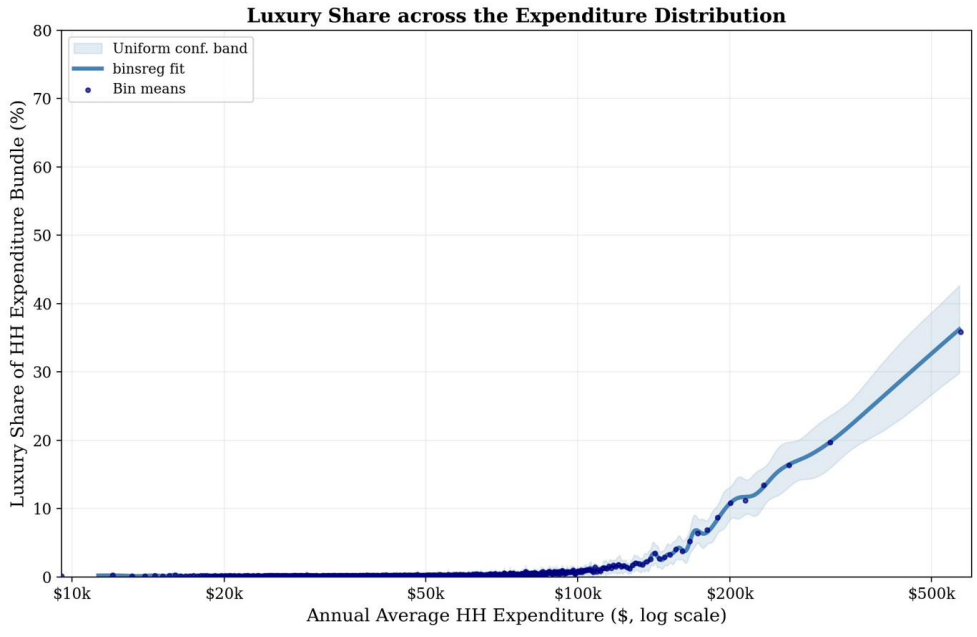
We now move from a curated list to an **automated, firm-side classifier**.

- **Definition.** Firm f is *luxury* if $> 50\%$ of its 5-year mapped sales goes to households in the top 1% of the expenditure distribution.
  - Similar results for other thresholds (e.g. top 5% or top 10%)
- **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)

$\Rightarrow$ *Broader luxury coverage, fully data-driven.*

Top-1% luxury Engel curve

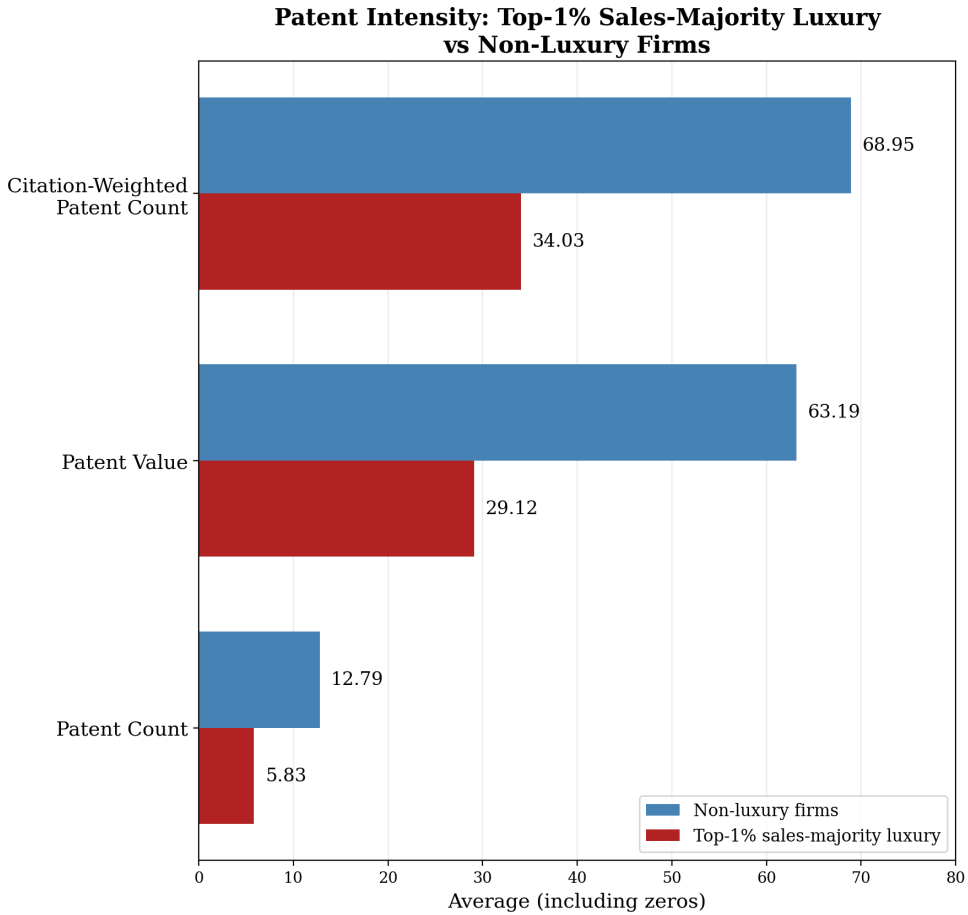




Top 1% expenditure share on luxuries: 30%; Bottom 99% <1%.

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:

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

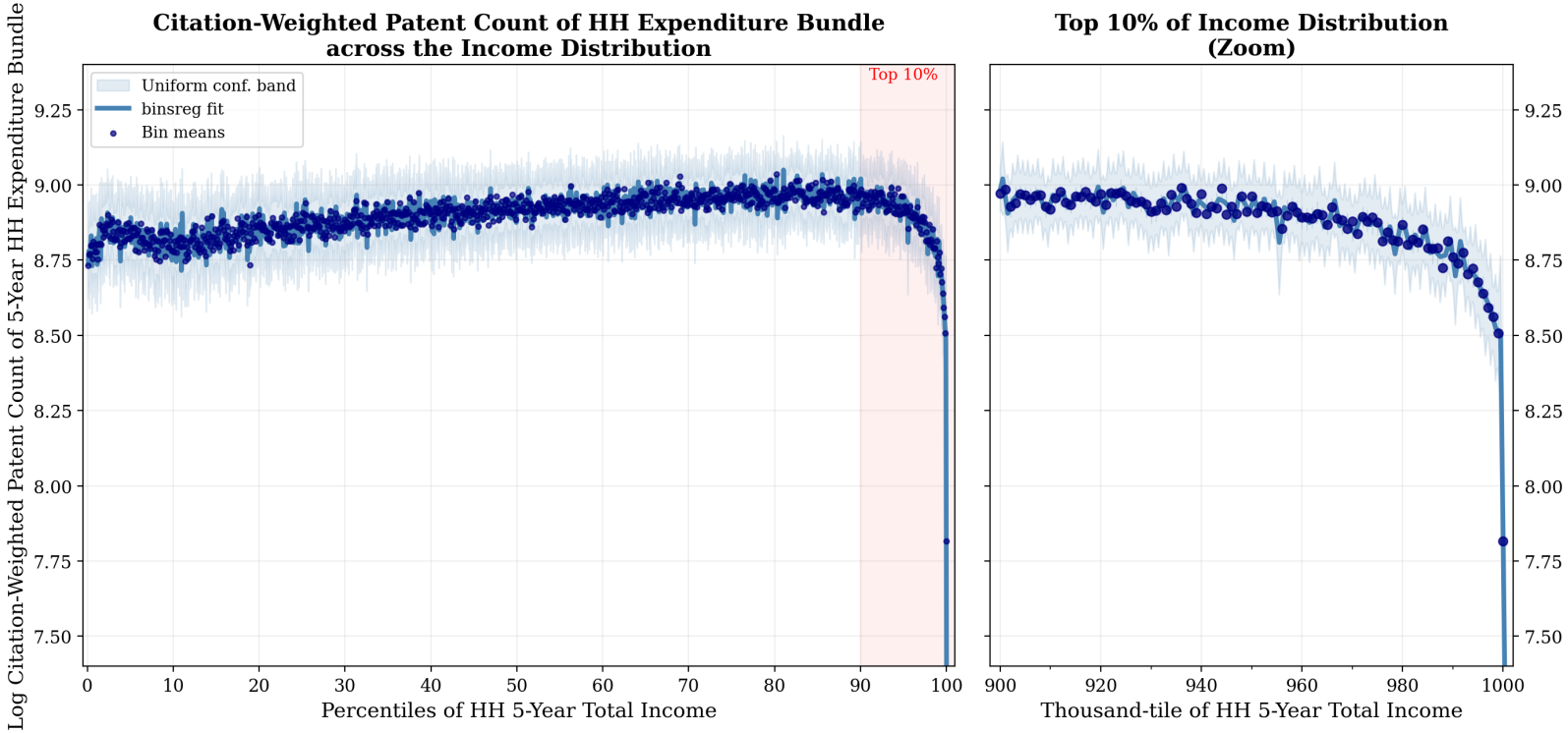
For an innovation measure M_f at the firm level, the **innovation intensity of h's consumption bundle** is:

$$\text{PV}_h = \sum_f \omega_{hf} M_f$$

Four candidate innovation measures M_f:

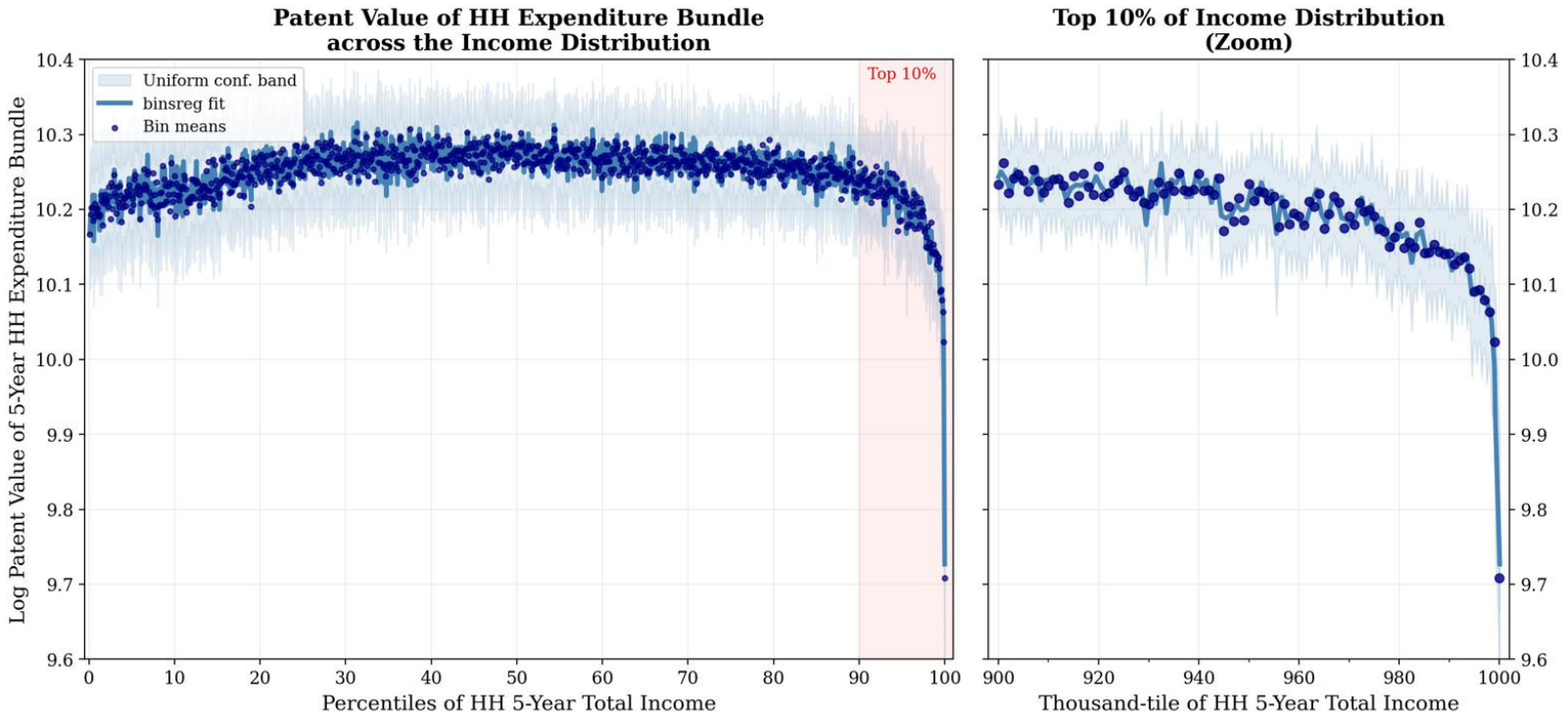
- Patent count
- Citation-weighted patent count
- Patent value (Kogan et al. 2017; Compustat firms only)
- Imputed patent value (via citation $\rightarrow$ value regression; extends to non-listed firms)

Innovation Engel Curve — citation-weighted patent count



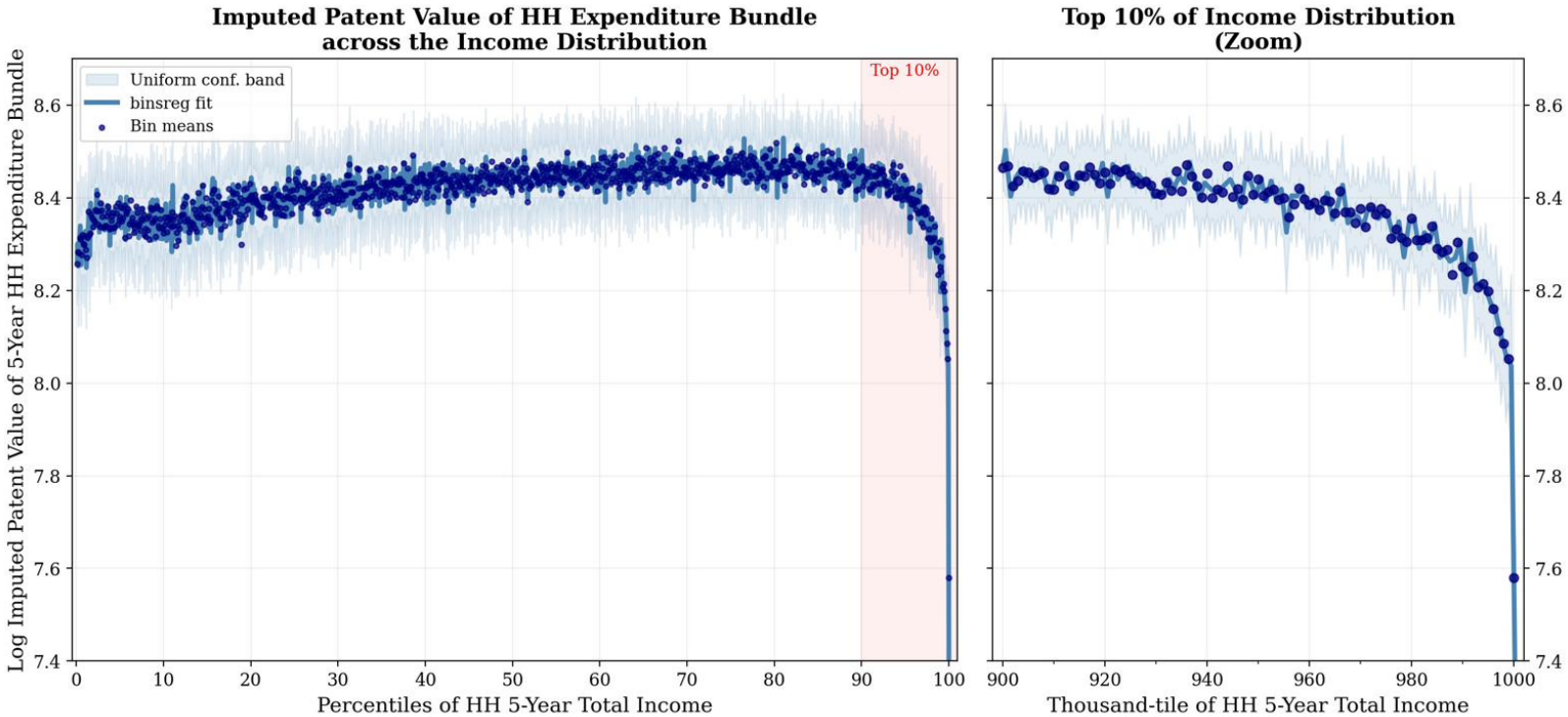
Top 1% income households' expenditure bundle is 35% less innovation-intensive when measured by citation-weighted patent counts.

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

$\Rightarrow$ *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:

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

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

- Utility compatible with balanced growth
- **Mass-Market bundle**: CES over n_t differentiated varieties $c_{i,t}(\epsilon)$
- **Exclusive** Q: no satiation, absorbs expenditure 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 — extra spending flows to luxuries

All that follows is a consequence of this non-homotheticity

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:

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

- 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 luxury 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 spending directed toward 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.

$\Rightarrow$ 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 $\Rightarrow$ ϵ^* is constant on the BGP.]

Optimal consumption

In symmetric eqm, consumption of each differentiated good:

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

- 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 spending 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

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

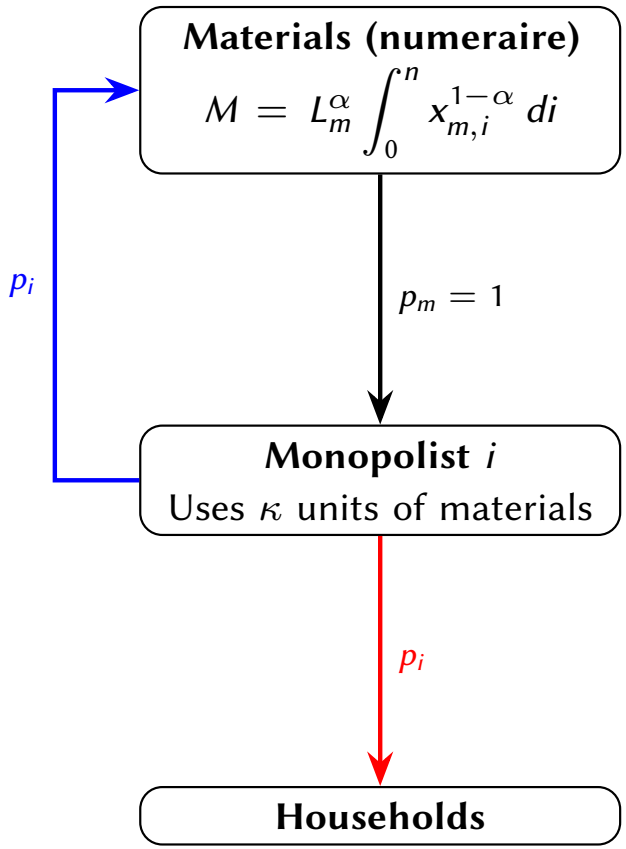
$$\downarrow$$

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) luxury goods produced with non-reproducible factor
(ii) measure of artisans is fixed.

Production structure: mass-market goods



- Materials producers are competitive
  - Materials are produced with labor and intermediate goods
  - The price of materials is 1 (numeraire)
  - Materials producers sell to varieties producers
- Producers of variety i are monopolistically competitive:
  - The produce variety i with materials
  - They supply variety i at price p_i to households and materials producers.

Monopolistic pricing when $\bar{c}$ is binding

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

$$p_i = \nu\kappa \frac{1}{1-(\nu-1)\dfrac{\left(1-\Gamma(\epsilon^*)\right)\bar{c}}{\frac{\bar{c}}{\epsilon^*}\int_{\epsilon_{\min}}^{\epsilon^*}\Gamma'(\epsilon)\,\epsilon\,d\epsilon + x_{m,i}}}$$

Or

$$p_i = \nu\kappa \frac{1}{1-\underbrace{(\nu-1)}_{>0}\dfrac{\text{inelastic demand}}{\text{elastic demand}}}$$

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.

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

$$\frac{1}{\Psi} = \frac{\pi_i}{r}.$$

- Since along the BGP

$$r = g + \rho$$

$$g = \psi\pi_i - \rho$$

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 luxuries
- Demand for mass-market goods now more inelastic: their markup ↑
- Aggregate demand for innovation-intensive mass-market goods falls
- Profits in the innovation-producing sector fall
- Entry of new varieties falls
- Growth and the real interest rate decline

Plan of the Talk

1. Introduction
2. Data
3. Model
4. **Quantitative analysis**
   - 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

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

- Choose η and $\epsilon_{\max}$ 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)

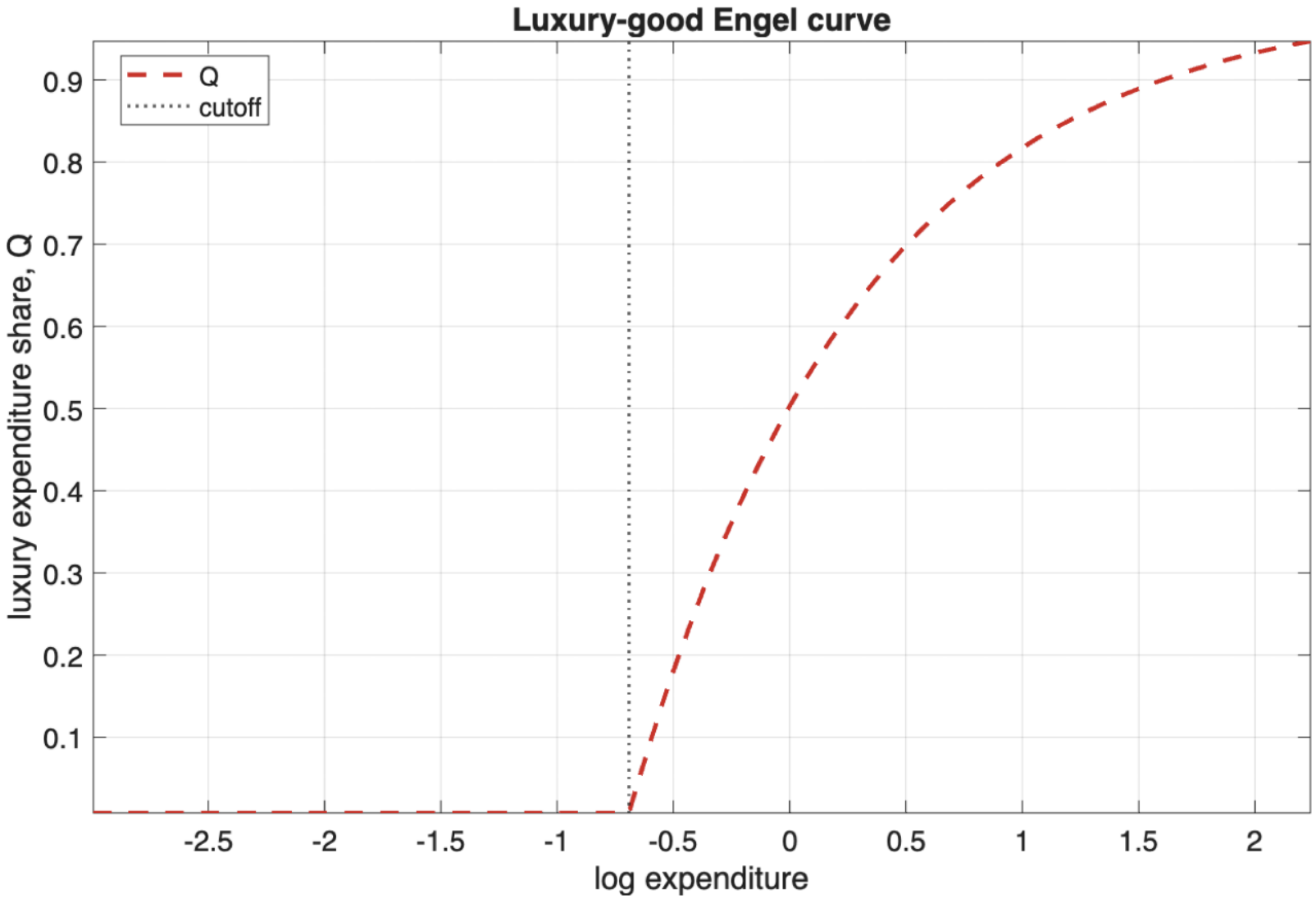
- Top income share target

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

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

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

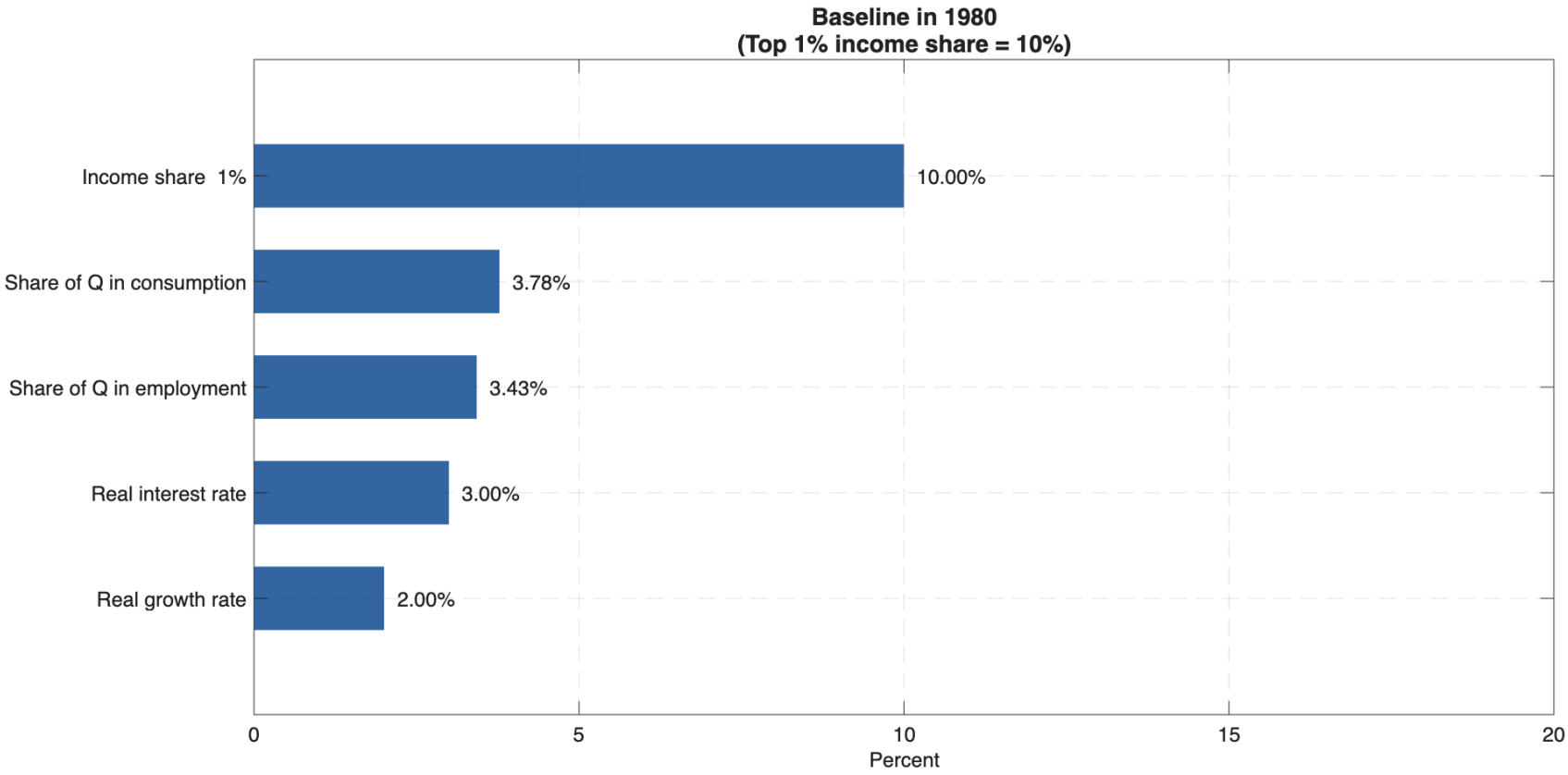
Model Engel curve



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

1980 baseline



US 2020 Income Distribution

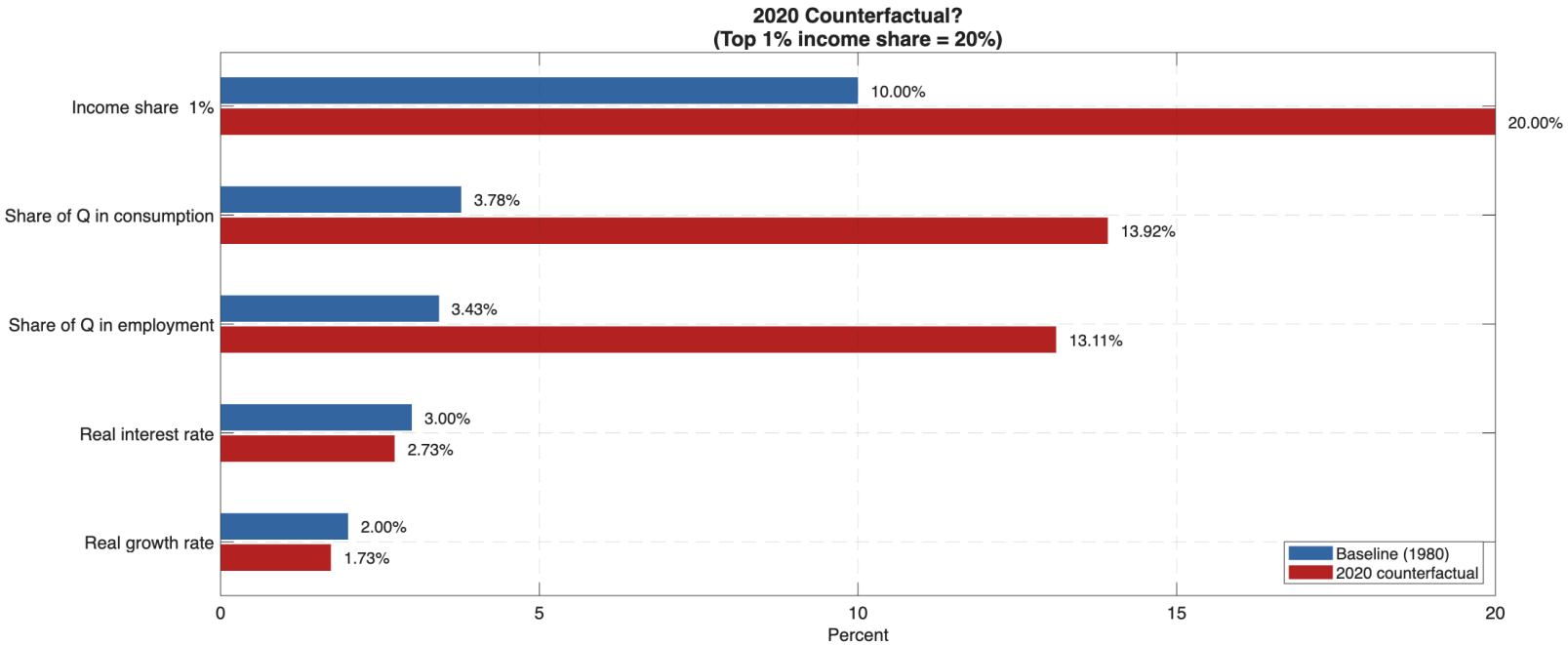
As inequality rises

- expenditure and employment shift toward the luxury sector
- profits in the mass-produced goods sector decline
- aggregate profits rise
- the real interest rate declines

Growth declines

- $g = 2.13\%$ in the 1980s vs. $g = 1.65\%$ in the 2010s
- Through the lens of the model, the inequality–innovation link accounts for 40% of this decline

1980 vs. 2020

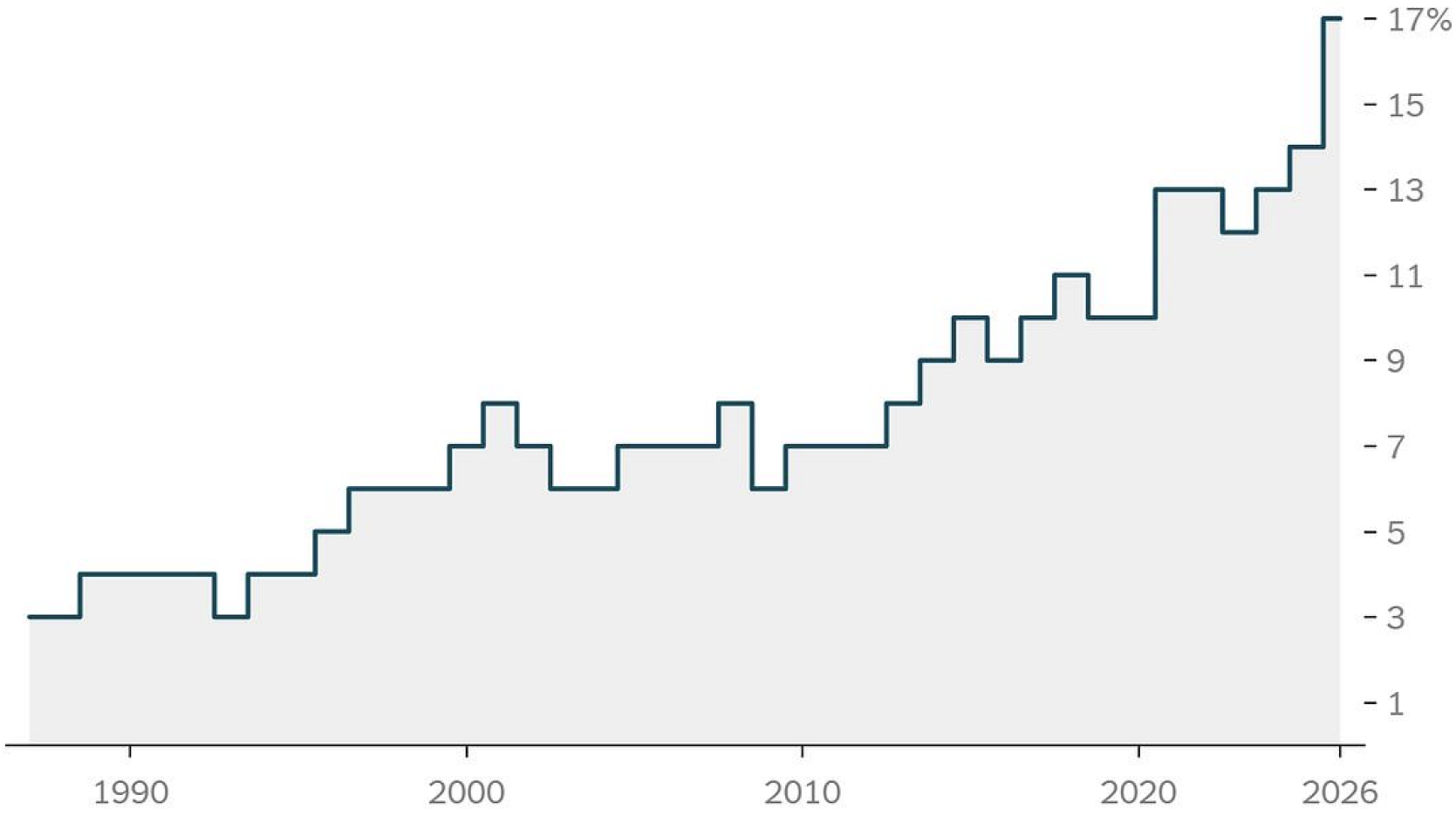

2020 Counterfactual?
(Top 1% income share = 20%)
Income share 1%
10.00%
20.00%
Share of Q in consumption
3.78%
13.92%
Share of Q in employment
3.43%
13.11%
Real interest rate
3.00%
2.73%
Real growth rate
2.00%
1.73%
Baseline (1980)
2020 counterfactual
0
5
10
15
20
Percent

1980 vs. 2020

Consistent with less dynamism in the U.S. economy before AI boom

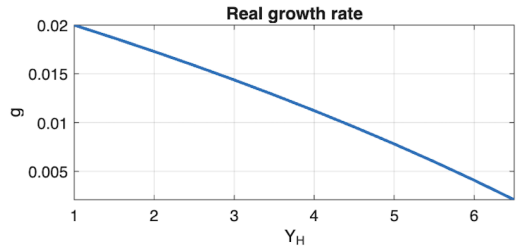
- Davis and Haltiwanger (2019) document that business formation rates declined.
- Gordon (2015) describes U.S. potential real GDP growth around 1.6%, roughly half the earlier 1972–2004 pace.
- Byrne, Fernald, and Reinsdorf (2016) document a slow down in productivity
- Laubach and Williams (2003) argue that real interest rate has declined

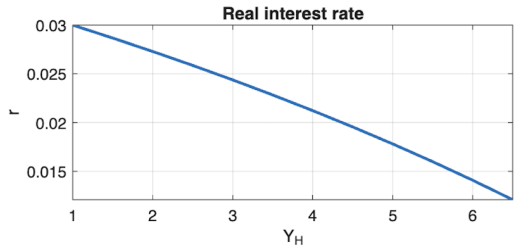
Wealth of top 0.0001% as share of global GDP

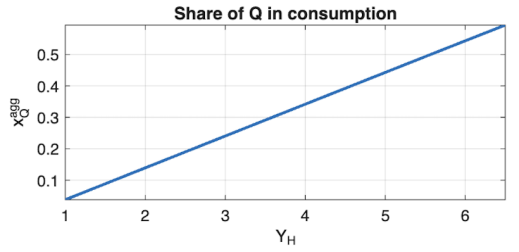


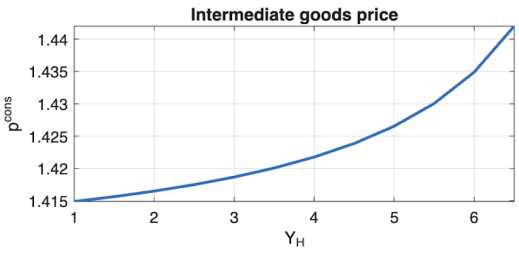
Source: Thomas Blanchet, Léonard Mouillet, Emmanuel Saez, and Gabriel Zucman.

Possible futures

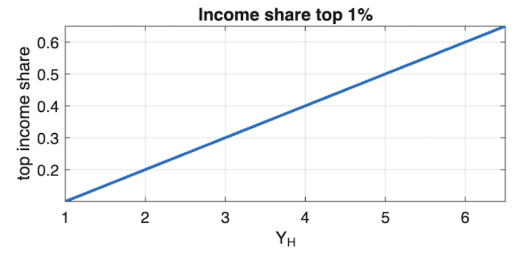


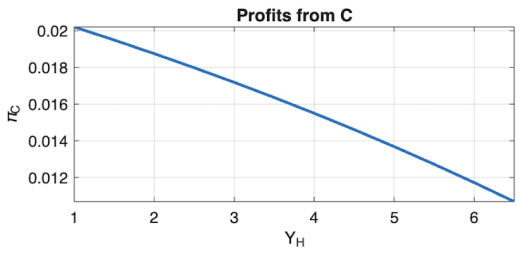


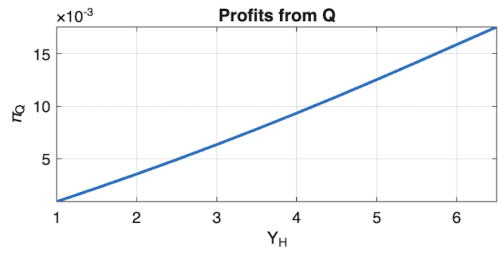


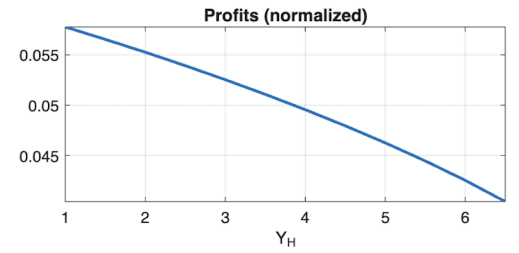












Model implications

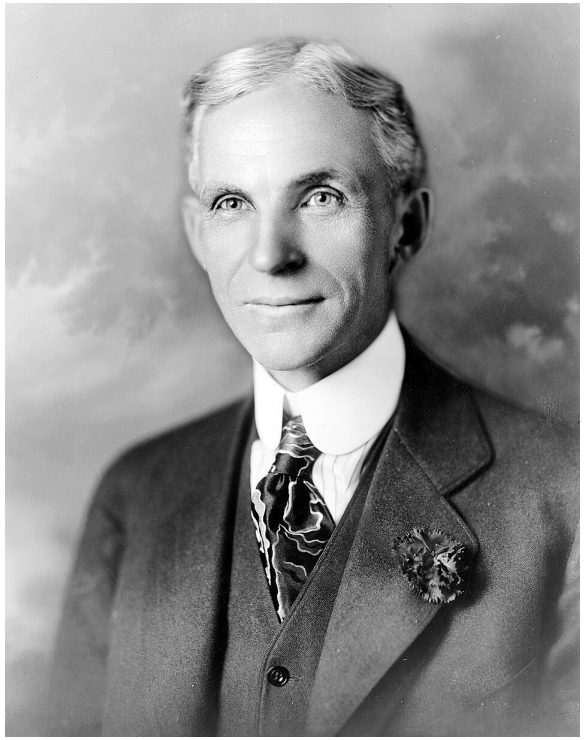
- A smaller, richer population can reduce innovation incentives
  - Holding aggregate income fixed, a smaller but richer population may place more households above the thresholds at which marginal spending shifts away from innovation-intensive goods, reducing demand for innovation.
- The mechanism can be relevant in open economies
  - Even when firms sell globally, domestic demand can shape innovation because exporters often develop, test, and refine products in their home markets before succeeding abroad, e.g. Bernard and Jensen (1999).
- High inequality can be a development barrier
  - Concentrated income weakens demand for mass-consumption goods and reduces incentives to innovate; exporting can mitigate this force, but may not fully substitute for domestic markets that help firms build capabilities before competing internationally.

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