Leisure-enhancing technological change

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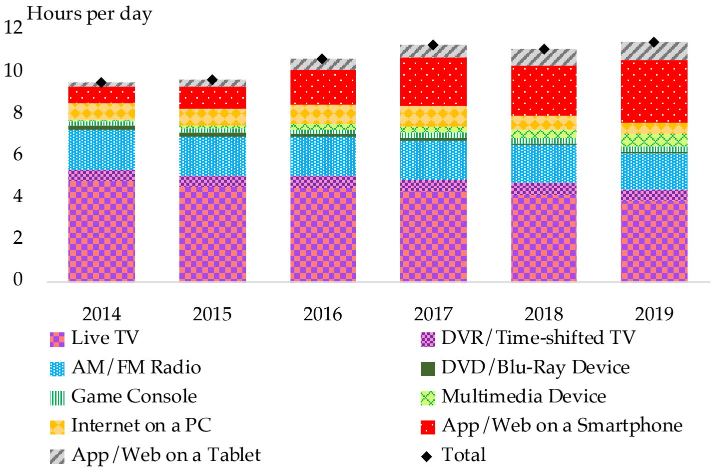
Motivating long-run facts

1. Sluggish productivity growth (despite rapid technological change)
2. Secular decline in hours worked (not in our macro growth models)
3. Importance of the free economy (zero-price services: radio, TV, websites, social media...)
4. Firm competition through non-price terms (the rise of marketing & intangible capital)

Dramatic changes in time allocation more recently

Daily time spent on various devices in the US



Source: Nielsen. Note: Representative sample of total US population (whether or not have the technology). Sample sizes vary across devices, with about 400,000 radios, 250,000 TVs and 10,000 smartphones tracked. More than one technology may be used at any time.

Use across average day

This paper

What I do

- develop a GE theory of free (zero price) leisure technologies
- study implications for innovation and growth

Key ingredients

- new activity-based framework for modelling leisure
- firm competition involves marketing, brands, intangible capital
- two-sided platforms

Key findings

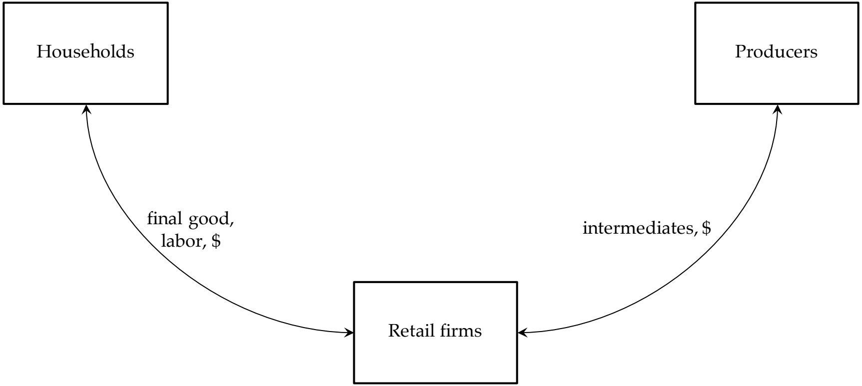
- the leisure sector emerges once the economy is large enough
- growth can be balanced, but conditions more stringent
- leisure technology $\uparrow \Rightarrow$ hours worked $\downarrow \Rightarrow$ productivity growth $\downarrow$
- measured GDP exaggerates the slowdown in activity
- two novel inefficiencies: static and dynamic, go in opposite ways

Plan for Today

1. Framework.
2. Analytical characterization of the growth process.
3. Illustrative parametrization.
4. Welfare.

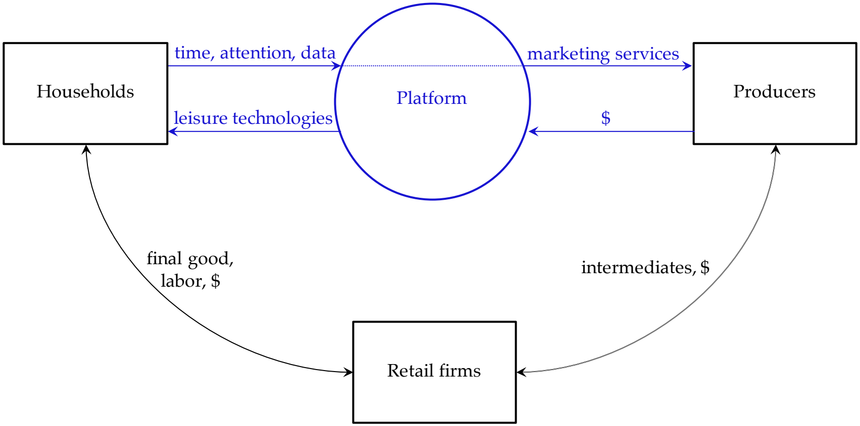
Model overview

- Start with a standard model of monopolistic competition, e.g. Dixit and Stiglitz (1977)



Model overview

- Start with a standard model of monopolistic competition, e.g. Dixit and Stiglitz (1977)
- Incorporate the leisure economy:



Leisure: activity-based framework

- N households. Population growth: $\frac{\dot{N}}{N} = n$
- Each household has balanced growth preferences over consumption and leisure:

$$u(c, l) = \log(c) + l$$

- Get utility from M leisure activities, indexed by j:

$$l = \left(\int_0^M \underbrace{[\min\{h(j), m(j)\}]}_{\text{activity}(j)}^{\frac{\nu-1}{\nu}} dj \right)^{\frac{\nu}{\nu-1}}, \qquad \nu > 1$$

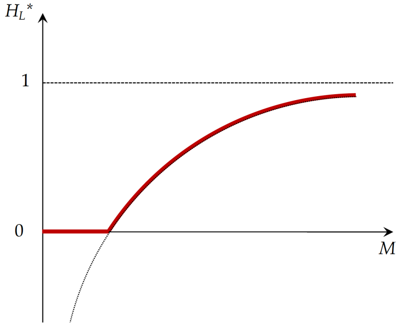
  - Love of variety. M indexes the state of leisure technology
  - Notation: $H_L := \int_0^M h(j)dj$
- Key: leisure $\neq$ leisure time. Instead, leisure depends on technology

Result 1: time use and technology

Proposition 1

Optimal leisure hours vary with technology:

$$H_L^* = \max\{0, 1 - M^{\frac{1}{1-\nu}}\}$$



- Key insight: leisure use increases with technology

  Gentzkow and Shapiro (2008), Olken (2009), Falck, Gold, and Heblich (2014), Reis (2015)

Production and competition through marketing

- Final good:

$$Y = \int_0^A \left(\left(\frac{b(i)}{\bar{B}} \right)^{\chi} x(i) \right)^{\alpha} L_Y^{1-\alpha} di$$

  - $b(i)$: marketing of firm i; $\bar{B}$: average marketing; $\chi \geq 0$: perceived effectiveness

- Demand for variety $x(i)$:

$$x(i) = \left(\frac{\alpha}{p(i)} \right)^{\frac{1}{1-\alpha}} \left(\frac{b(i)}{\bar{B}} \right)^{\frac{\alpha\chi}{1-\alpha}} L_Y$$

- In symmetric equilibrium, no firm gains (Bagwell (2007))
- Producer i has access to CRS technology: $x(i) = X$, demands marketing services:

$$p_B = \alpha^{\frac{2}{1-\alpha}} \chi \frac{1}{b(i)} \left(\frac{b(i)}{\bar{B}} \right)^{\frac{\alpha}{1-\alpha}\chi} L_Y$$

R&D sector: growth through by profit-driven innovation Romer 1990, Jones 1995

- Research expands the range of intermediate products, generating growth
- R&D firms employ researchers L_A and build on existing ideas A to generate a flow of new patents:

$$\dot{A} = A^{\phi} L_A^{\lambda}$$

  - $\phi < 1$: "ideas are getting harder to find" (Jones (1995), Bloom et al. (2017))

- Profit maximization:

$$\max_{L_A} P_A \dot{A} - w L_A$$

- Free entry:

$$w L_A = P_A \dot{A}$$

The platform

Objective | ▸ Maximize profits: $\pi_{\text{platform}} = p_B \cdot B - \mathbb{C}(B)$, where $B := \int_0^A b(i)di$.

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Technologies

1. IRS technology to produce B2B marketing services:

$$B = F^B(H_L^*) = \frac{1}{1 - H_L^*} \quad \text{if} \quad H_L^* > 0, 0 \text{ otherwise}$$

   - Increasing returns required for balanced growth since $H_L^* \in [0, 1]$

2. CRS technology to produce leisure varieties:

$$M = F^M(X_M, L_M) = X_M$$

The platform

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Constraints

$$H_L^* = \max\{0, 1 - M^{\frac{1}{1-\nu}}\} \qquad p_B = \alpha^{\frac{2}{1-\alpha}\chi} \frac{1}{b(i)} \left(\frac{b(i)}{\bar{B}}\right)^{\frac{\alpha}{1-\alpha}\chi} L_Y$$

$\Rightarrow$ cost function: $\mathbb{C}(B) = \begin{cases} +\infty & \text{if } X_M^* \leq 1 \\ B^{\nu-1} & \text{if } X_M^* > 1 \end{cases} \Rightarrow$ minimum scale of operation

Result 2: market size effect for the leisure economy

Proposition 2

The platform is active iff:

$$(1-s)\cdot A(t)\cdot N(t) > \frac{1}{\kappa},$$

where $s := \frac{L_A}{L_A+L_Y}$ *and* κ *is a constant.*

Intuition:

- M must be sufficiently high to move HHs away from the corner of $H_L^* = 0$
- This is profitable only when the market is sufficiently large
- This is the market size effect for the leisure economy

Result 3: growth along the segmented balanced growth path (sBGP)

Proposition 3

Initially, the growth rate of the economy is:

$$\gamma_0 = \frac{\lambda n}{1-\phi}.$$

Asymptotically, average hours worked decline at a constant rate $\gamma_H = -\frac{1}{\nu}(\gamma_A + n)$, *and the growth rate of* A *is given by:*

$$\gamma_A = \frac{\lambda n^{\frac{\nu-1}{\nu}}}{1-\phi+\frac{\lambda}{\nu}} < \gamma_0$$

- The leisure economy causes a decline in aggregate TFP growth
- Intuition: slower expansion of hours (key to generating ideas)
- Related to scale effects in endogenous growth literature

How big may these effects be?

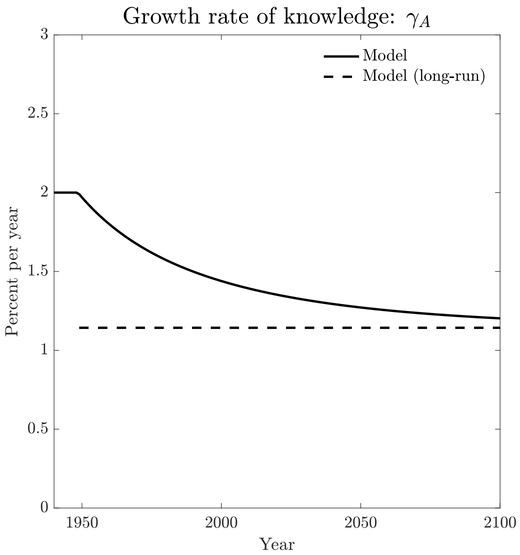
- Cautious illustrative partametrization:

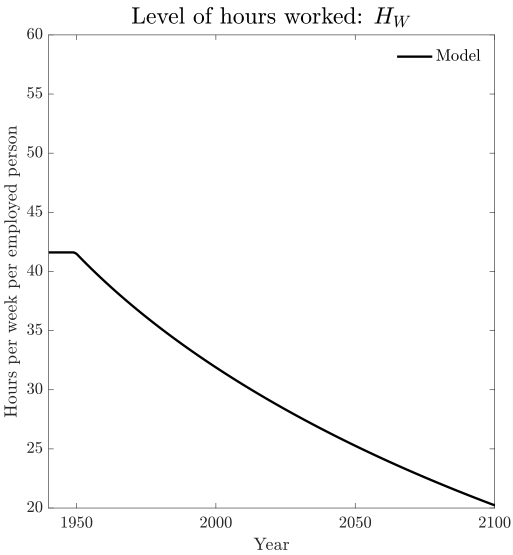
Parameter	Description	Value	Target / source
ρ	Household discount rate	0.02	$r \approx 4\%$
n	Population growth	0.01	AEs data
α	Share of consumer goods in Y	0.33	Jones (1995)
λ	returns to labor in R&D	1.8	$\gamma_0 \approx 2\%$
ϕ	returns to ideas in R&D	0.1	Bloom et al. (2017)
ν	Elasticity of substitution between leisure activities	5	see below
χ	Perceived effectiveness of marketing	0.05	see below

- High ν:
  - internet vs. everything else: ≈ 1.5 (Goolsbee and Klenow (2006))
  - cars imported from different countries ≈ 3 (Broda and Weinstein (2006))

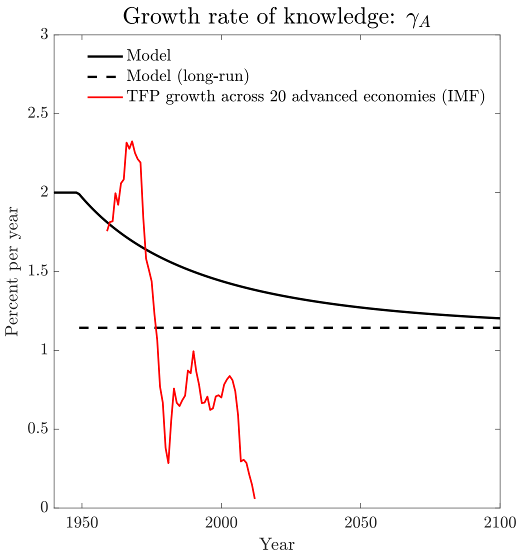
- Low χ: implies perceived elasticity of 0.025.
  - US micro-estimates: Beer: 0.0, Wine: 0.08, Cigarettes: 0.04, Recreation: 0.08

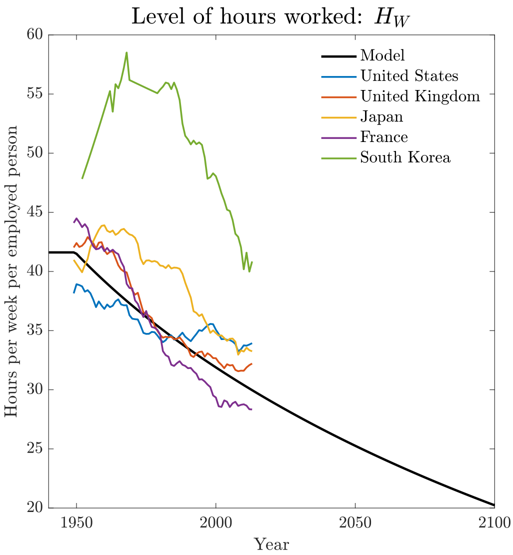
Simulated segmented balanced growth path, $\hat{t} = 1950$ Details





Comparison with historical experience, $\hat{t} = 1950$





Measurement challenge

Bean (2016):

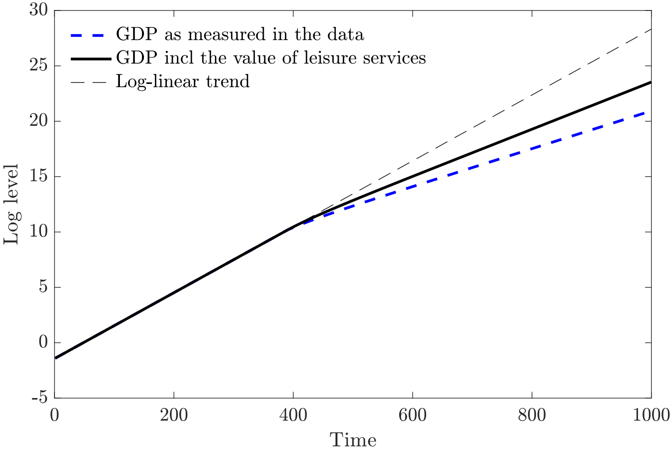
> *Most of the web's popular destinations, such as Google, Facebook, and YouTube, rely on advertising to generate income. Digital products and services are effectively paid for by the advertisers. As such, the 2008 UN System of National Accounts treats them as an intermediate input in the advertising industry.*

- Leisure services not in GDP, as currently measured
- Use the model for counterfactual measurement, e.g. value leisure time at equilibrium wages (Goolsbee and Klenow (2006), Brynjolfsson and Oh (2012)):

$$V_{leisure} = (1-\alpha)\alpha^{\frac{2\alpha}{1-\alpha}} AN \left(1 - (\kappa(1-s)AN)^{-\frac{1}{\nu}}\right)$$

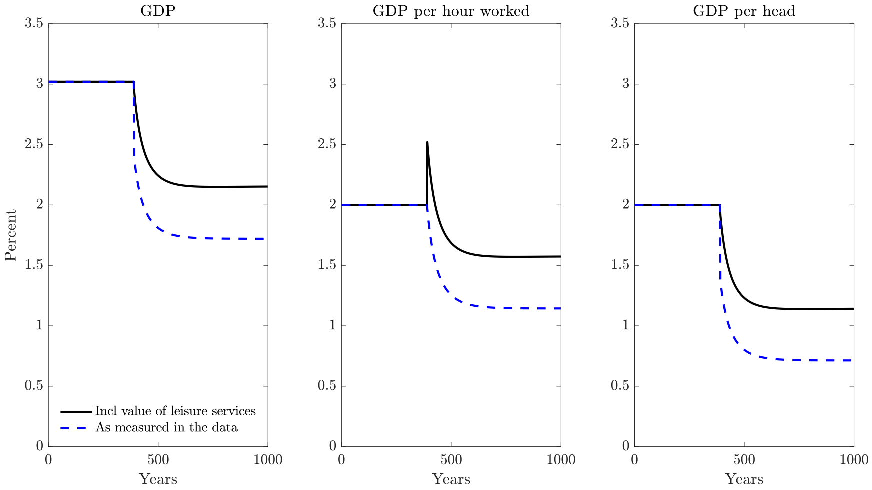
$$GDP_{inc.\ leisure} = \begin{cases} AN(1-s)\left(\alpha^{\frac{2\alpha}{1-\alpha}} - \alpha^{\frac{2}{1-\alpha}}\right) & \text{if } t < \hat{t} \\ (AN)^{\frac{\nu-1}{\nu}}(1-s)^{\frac{\nu-1}{\nu}}\kappa^{-\frac{1}{\nu}}\left(\alpha^{\frac{2\alpha}{1-\alpha}} - \alpha^{\frac{2}{1-\alpha}} - \kappa\right) + V_{leisure} & \text{if } t \geq \hat{t} \end{cases}$$

GDP along the sBGP



- Adding the value of leisure services $\Rightarrow$ smaller slowdown. But still a slowdown!
- Intuition: Ultimate source of growth is the real economy, not the leisure sector

GDP and productivity growth



- Leisure economy lowers GDP growth & introduces mismeasurement in growth rates
- Sharp contrast to earlier papers, e.g. Syverson (2017) shares

Welfare

Two new inefficiencies related to leisure technologies:

1. Static: leisure services only a byproduct (Spence and Owen (1977)) $\rightarrow$ undersupply
2. Dynamic: the growth externality $\rightarrow$ oversupply
   - Socially optimal allocation satisfies:

$$\underbrace{c^{-1}A(1-s)\hat{\alpha}}_{\text{static marginal cost of leisure}} + \underbrace{\mu\zeta\lambda A^{\phi}(sH_W N)^{\lambda-1}s}_{\text{dynamic marginal cost of leisure}} = \underbrace{X_M^{\frac{1}{\nu-1}}}_{\text{marginal utility of leisure}}$$

   - The dynamic cost not internalized in market equilibrium

Conclusion

This paper

- develops a tractable theory of free leisure technologies
- incorporates it into the endogenous growth framework

Key results

- the leisure sector emerges endogenously on the growth path
- growth can be balanced, but conditions more stringent
- leisure technology $\uparrow \Rightarrow$ hours worked $\downarrow \Rightarrow$ productivity growth $\downarrow$
- measured GDP exaggerates the slowdown in activity
- rich welfare implications: static and dynamic inefficiencies

Potential applications

- explore policy implications of leisure technologies
- assemble empirical evidence guided by the theory
- construct novel measures of activity suitable for the modern economy

Thank you!

Motivating fact #1: falling productivity growth

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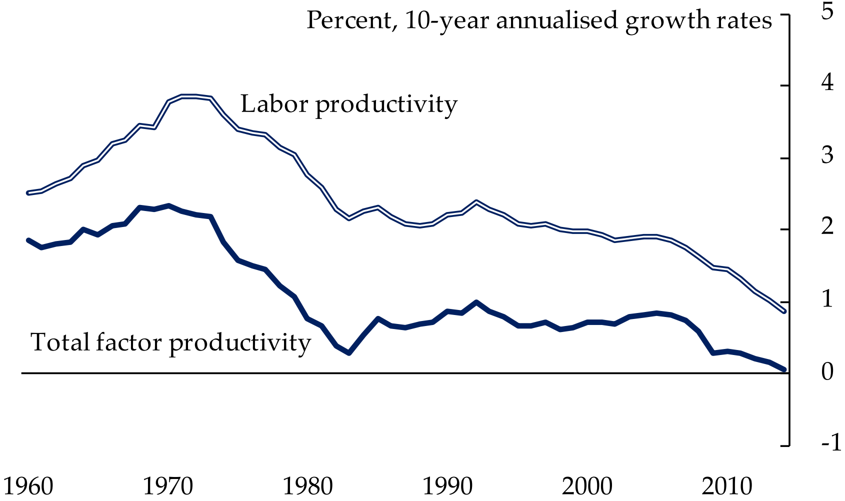

Sources: Penn World Table 9.0; IMF, World Economic Outlook. Note: Purchasing power parity GDP-weighted average of the largest 20 advanced economies.

Motivating fact #2: downward trend in hours worked...

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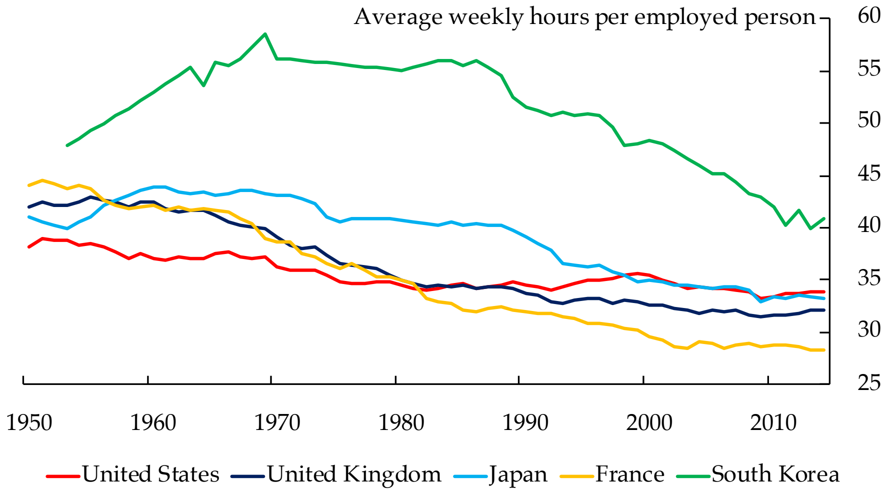

Source: Penn World Table 9.0.

Motivating fact #3: importance of the "free" economy

Share of ad-supported free consumer content in US GDP

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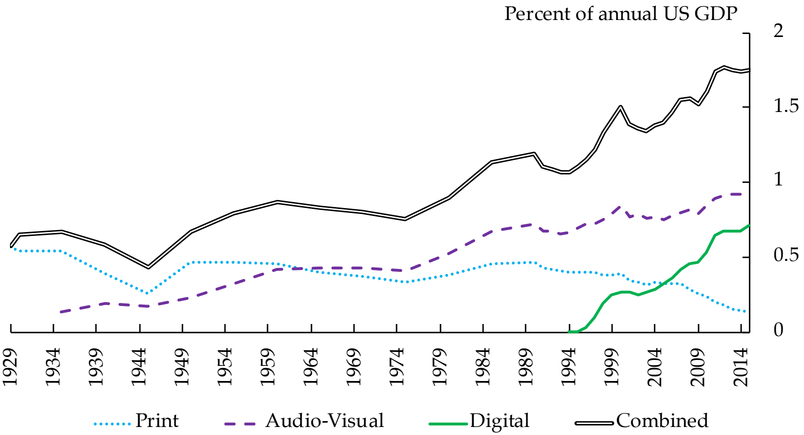

Source: Nakamura, Samuels, and Soloveichik (2017) Note: US data. The figure shows the ratio of free consumer content, measured by the costs of production, to GDP. Thus, for example, it does not capture a welfare measure of the value of Facebook, but only measure the cost of providing it.

Motivating fact #4: intangible capital

Intangible investment and capital

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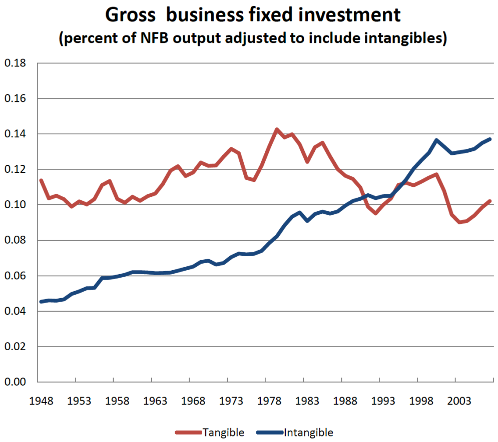
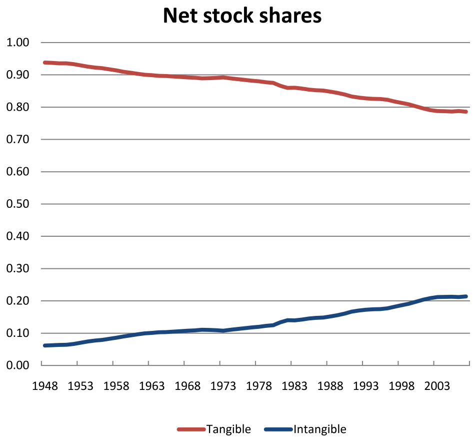
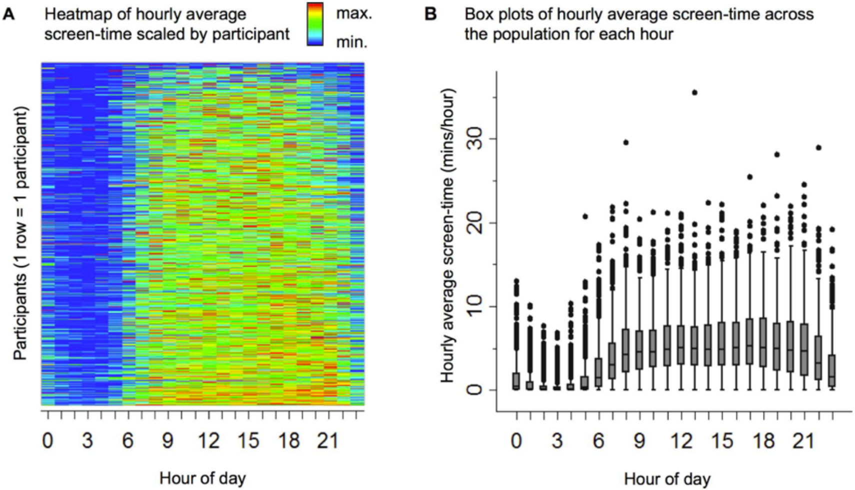




Source: Corrado and Hulten (2010) AER

The work-leisure margin

Daily pattern of smartphone use Back

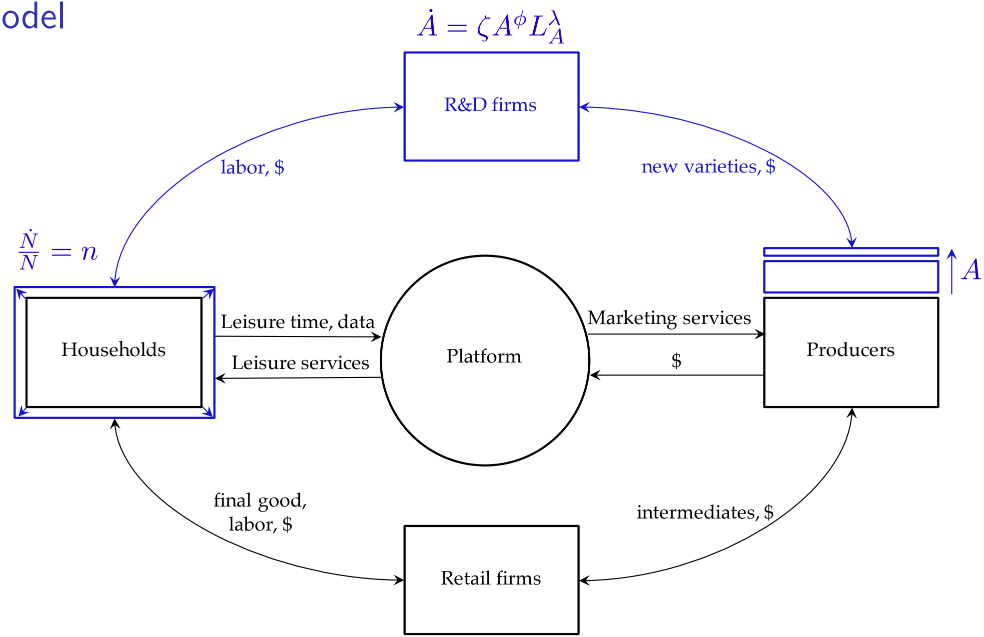


Source: Christensen et al. (2016).
Note: US data on 653 participants.

Related literatures

Endogenous growth	Romer (1990); Grossman and Helpman (1991); Jones (1995); Kortum (1997); Segerstrom (1998); Ngai and Pissarides (2008); Acemoglu and Guerrieri (2008); Lucas and Moll (2014); Boppart and Krusell (2016); Bloom et al. (2017); Farboodi and Veldkamp (2019)
Time allocation	Becker (1965); Goolsbee and Klenow (2006); Aguiar and Hurst (2007); Wallsten (2013); Christensen et al. (2016); Boik, Greenstein, and Prince (2016); Aguiar and Hurst (2016)
Productivity & measurement	Gordon (2016); Brynjolfsson and McAfee (2014); Brynjolfsson and Oh (2012); Byrne, Fernald, and Reinsdorf (2016); Nakamura, Samuels, and Soloveichik (2017); Syverson (2016); Bean (2016); Bridgman (2016); Bloom et al. (2017); Brynjolfsson, Rock, and Syverson (2017)
Two-sided markets	Marshall (1890); Chamberlin (1933); Spence and Owen (1977); Anderson and Coate (2005); Anderson and Renault (2006); Bagwell (2007); Rochet and Tirole (2003); Armstrong (2006); Tirole (2017)

Full model



$\dot{A} = \zeta A^{\phi} L_A^{\lambda}$
R&D firms
labor, $
new varieties, $
$\frac{\dot{N}}{N} = n$
A
Households
Leisure time, data
Leisure services
Platform
Marketing services
$
Producers
final good,
labor, $
intermediates, $
Retail firms

Household problem

Households solve the following problem: back

$$\max_{\{c(t)\}_0^\infty \{h(j)\}_0^M} \int_0^\infty e^{-(\rho-n)t} u(c,l)dt$$

subject to:

$$\dot{d} = d(r-n) + w \cdot (1 - H_L) - c$$

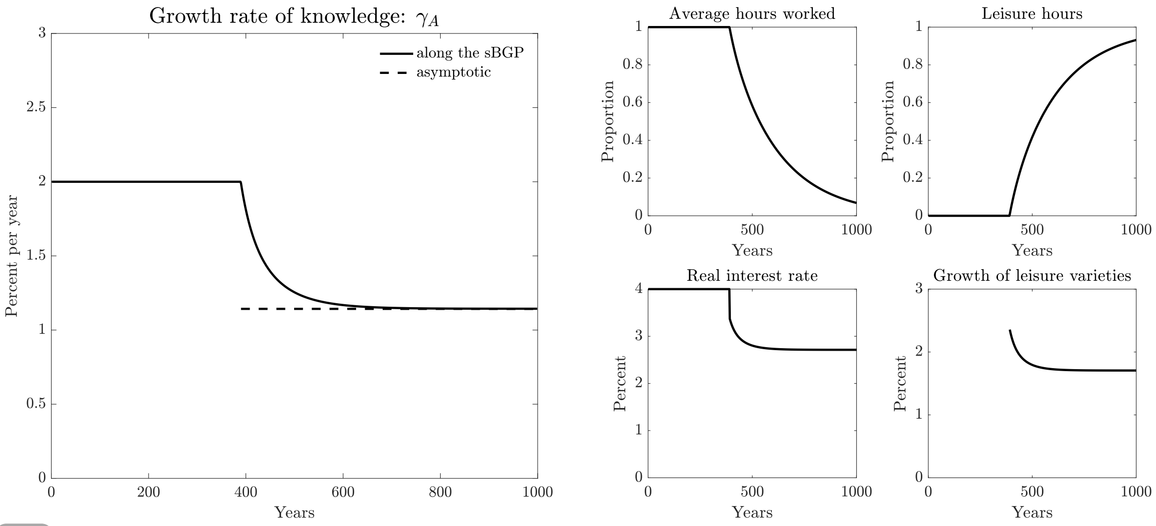
$$H_L = \int_0^M h(j)dj$$

$$l = \left(\int_0^M [\min\{h(j), m(j)\}]^{\frac{\nu-1}{\nu}} dj \right)^{\frac{\nu}{\nu-1}}$$

$$0 \leq \lim_{t\to\infty} \left[d \cdot \exp\left(- \int_0^t (r(s) - n)ds \right) \right]$$

where the instantaneous utility function is given by $u(c,l) = \log(c) + l$.

The growth path



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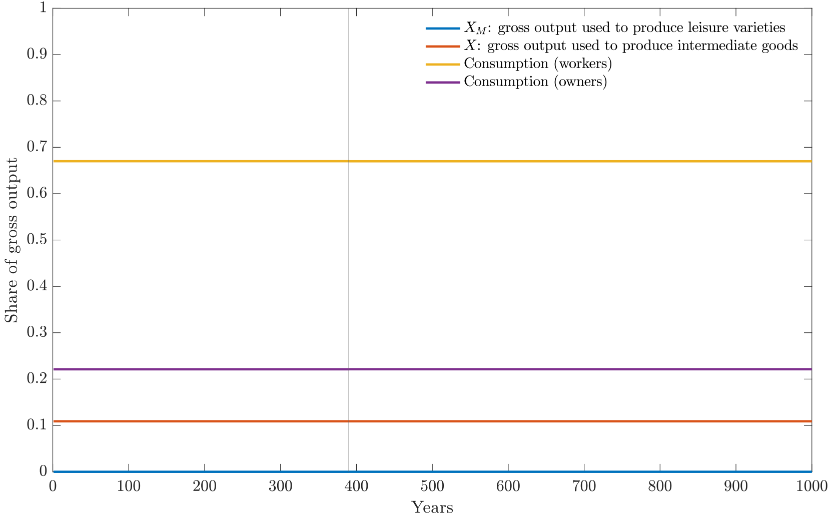
Shares in gross output



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