# Transformative AI, existential risk, and real interest rates

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[1]Stanford,   [2]University of Virginia,   [3]Oxford

December 2025

# AI researchers expect economic growth to accelerate

> **AGI could create about $100 trillion in new wealth – roughly doubling the world's GDP –** that actually sounds quite plausible to me.
>
> **— Sam Altman, CEO of OpenAI**

# AI researchers expect economic growth to accelerate



We are likely to see **periods of 4 years in the future that experience more change than the last 200.**

**— Paul Christiano, head of AISI & inventor of RLHF**

# Investment is booming

Hyperscaler capex is 1% of GDP:



**Capital expenditures, quarterly**

$100 billion

- Meta
- Google
- Microsoft
- Amazon

75

50

25

0

2018  '19  '20  '21  '22  '23  '24  '25
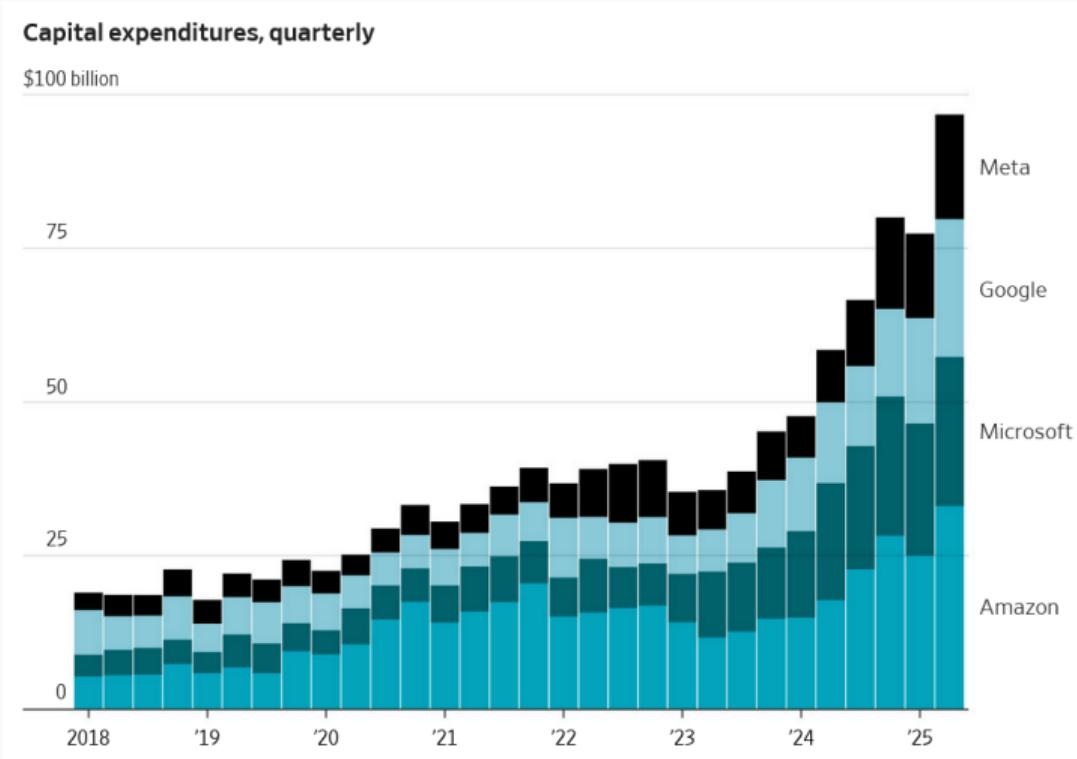
**Investment is booming**



Capex as % of GDP, by episode
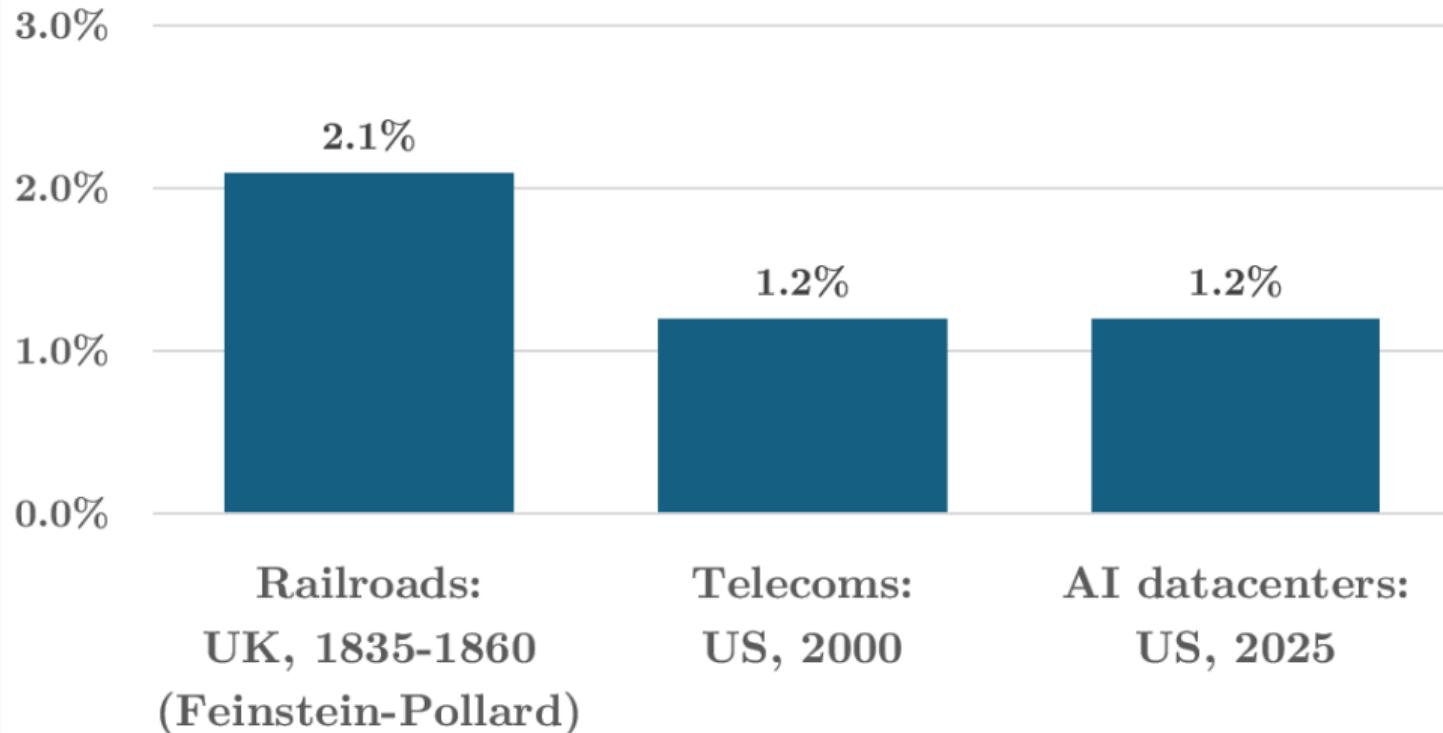
# Economists are, on average, measured about AI impacts

**AI will cause a "substantial increase" in GDP per capita growth** over next 20 years:

4
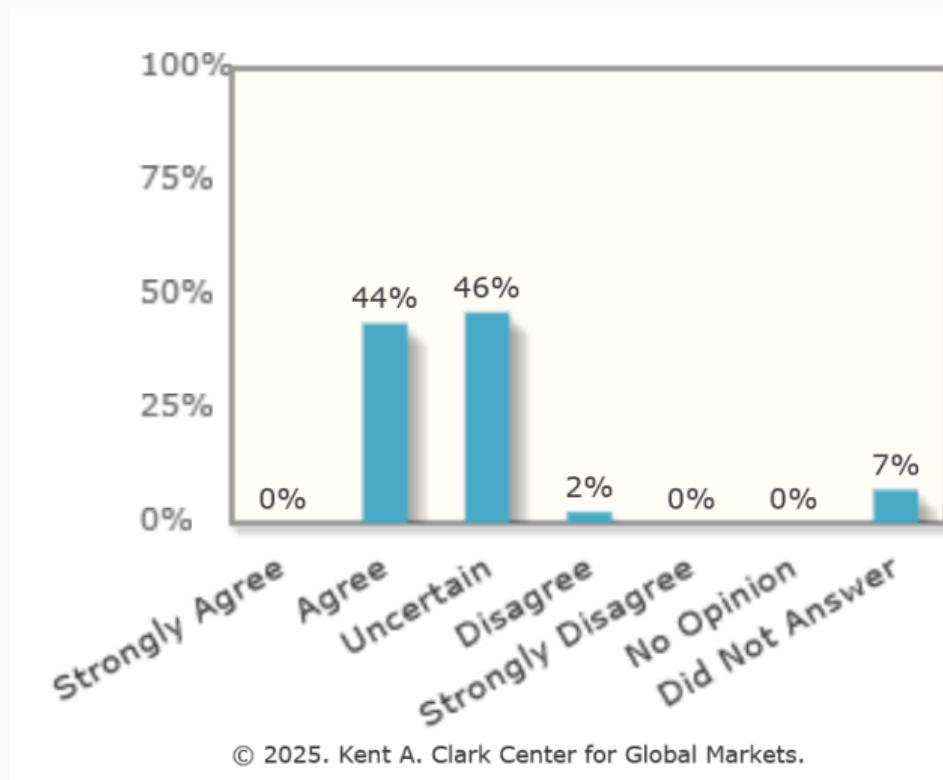
# Econ prior: stable 2% GDP growth
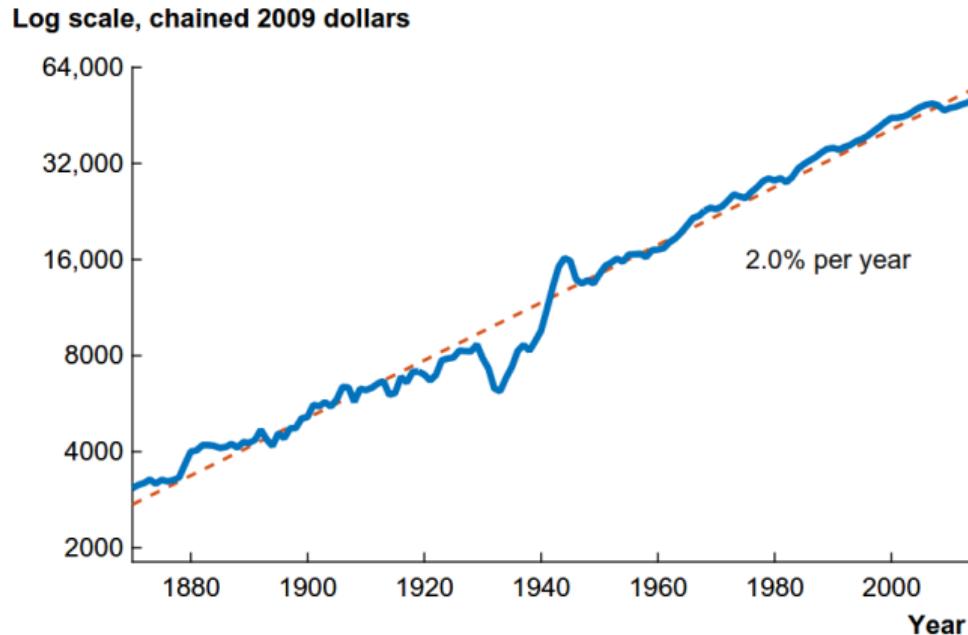


**Fig. 1** GDP per person in the United States. Source: *Data for 1929–2014 are from the U.S. Bureau of Economic Analysis, NIPA table 7.1. Data before 1929 are spliced from Maddison, A. 2008. Statistics on world population, GDP and per capita GDP, 1-2006 AD. Downloaded on December 4, 2008 from* http://www.ggdc.net/maddison/.
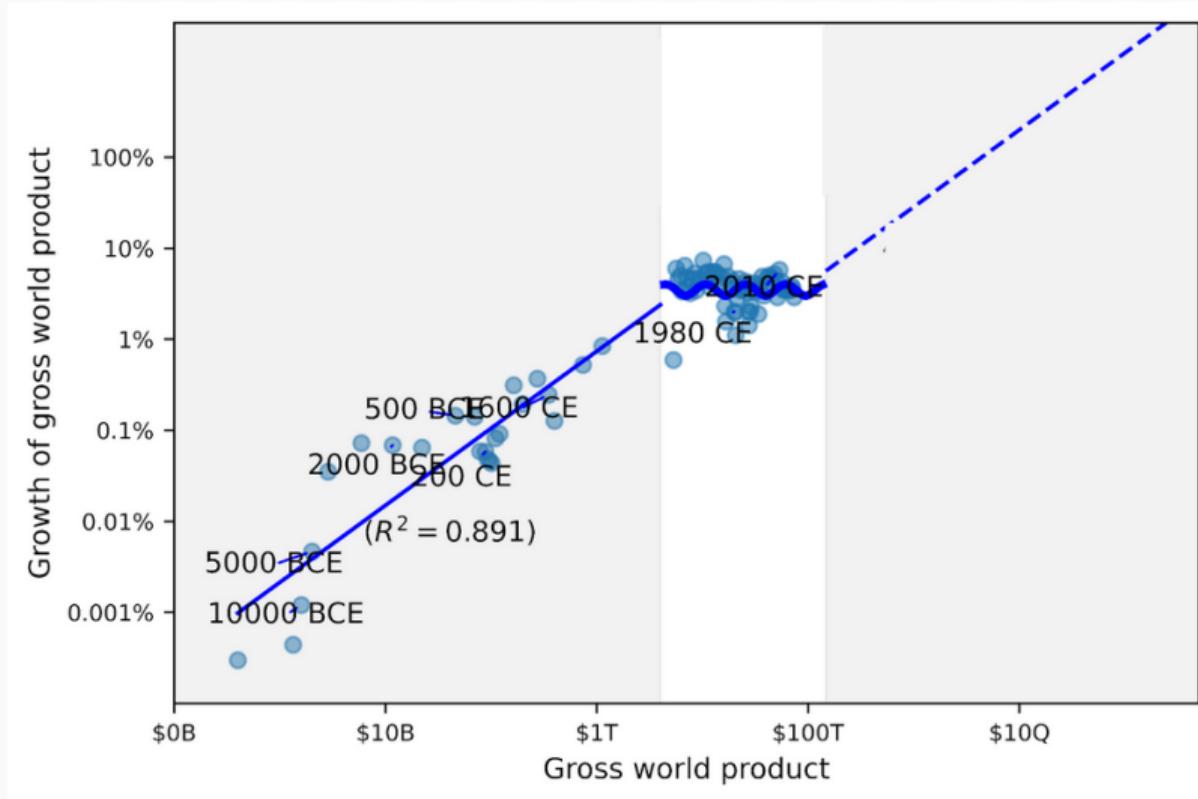
## Theory: growth explosion is *possible*

Once machines can produce ideas, the limits to growth may no longer hold, and **growth rates could speed up, potentially even leading to a so-called 'singularity'** with infinite consumption

— Jones (2024)

$$\underbrace{\frac{\dot{A}_t}{A_t}}_{\text{TFP growth}} = \underbrace{A_t^{-\beta}}_{\text{ideas getting harder to find}} \cdot L_t^{\alpha} K_t^{\beta}$$

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## 4. Asset prices

- ▸ Prices aggregate dispersed wisdom (Hayek 1945)…
- ▸ …financial market prices especially so (Fama, etc)

▸ examples

**This paper: a framework for contrasting *market expectations* of transformative AI vs. researcher beliefs**

# This paper: a framework for contrasting *market expectations* of transformative AI vs. researcher beliefs

**Central point:** short timelines for <u>transformative AI</u> would *increase real interest rates*

## "Transformative AI": defining the scenario under consideration

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Technology that causes growth in global GDP in excess of 30% per year.

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**Definition (*Un*aligned AI)**
Technology that causes human extinction.

# The basic logic

$$1 = \beta \mathbb{E}_t \left[ \frac{U'(C_{t+1})}{U'(C_t)} \right] (1 + r_t)$$

**Ramsey rule:**

$$r = \rho + \frac{1}{\sigma}g$$

- ▶ $r$: real interest rate
- ▶ $\rho$: time discounting
- ▶ $g$: growth rate
- ▶ $\sigma > 0$: elasticity of intertemporal substitution

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1. **Time discounting and mortality risk**

   - · "Intrinsic preference for the present"
     +
     Probability of death
   - · Intuition: no reason to save if dead

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2. **Economic growth**

   - · Intuition: consumption smoothing ("no reason to save if going to be rich")

## Real interest rates and transformative AI

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**Aligned transformative AI:** $g = 30\%$

**Example calibration:** $\rho = 1\%, \sigma = 1, g = 1\%$
Then:

$r = 2\%$

vs.

$r = 31\%$ **!**

**Recent history of real rates: at normal levels, though have risen**

10-year real rate

# Recent history of real rates: at normal levels, though have risen



10-year real rate

Legend:
- **median** (black)
- US (blue)
- UK (green)
- Australia (purple)
- Canada (gray)
- Nov. 2021
- Dec. 2025

# Recent history of real rates: at normal levels, though have risen



## 30-year real rate

legend:
- median
- US
- UK
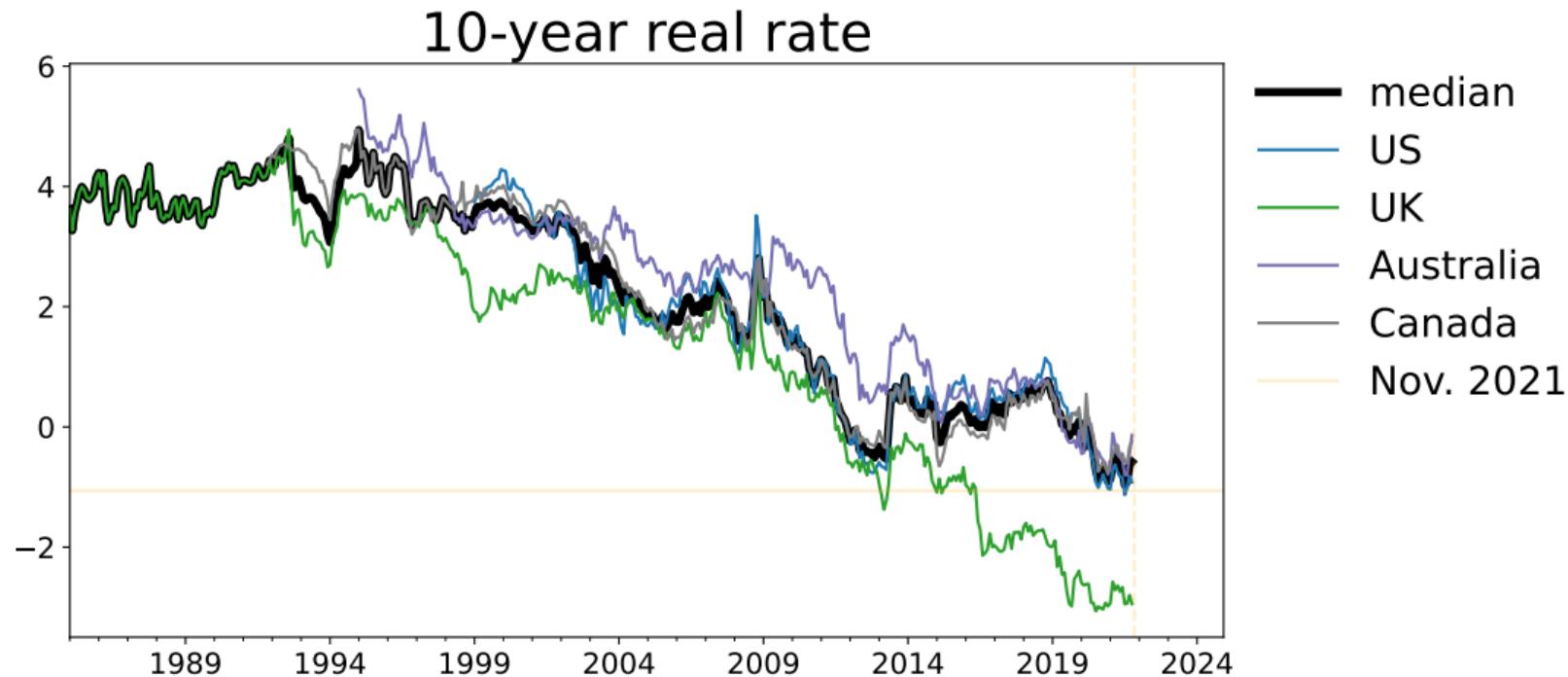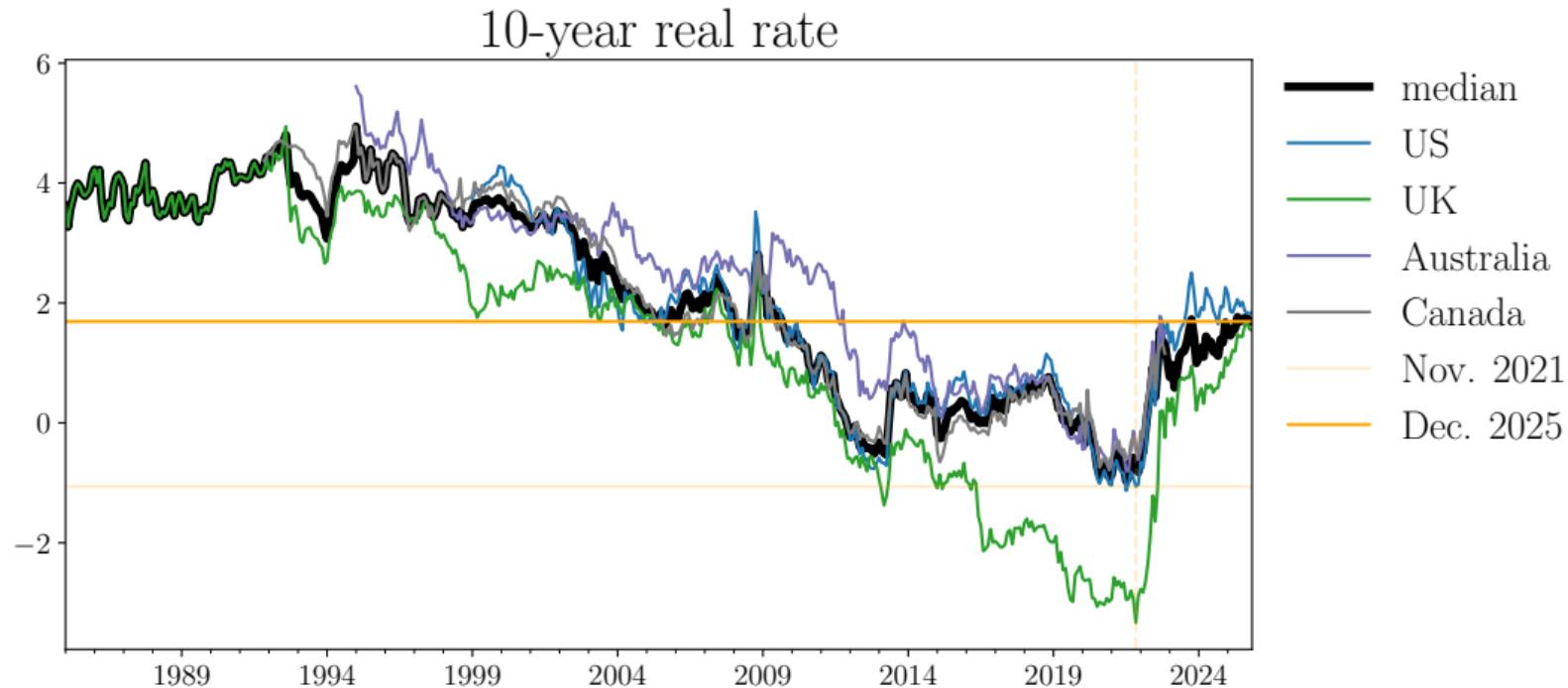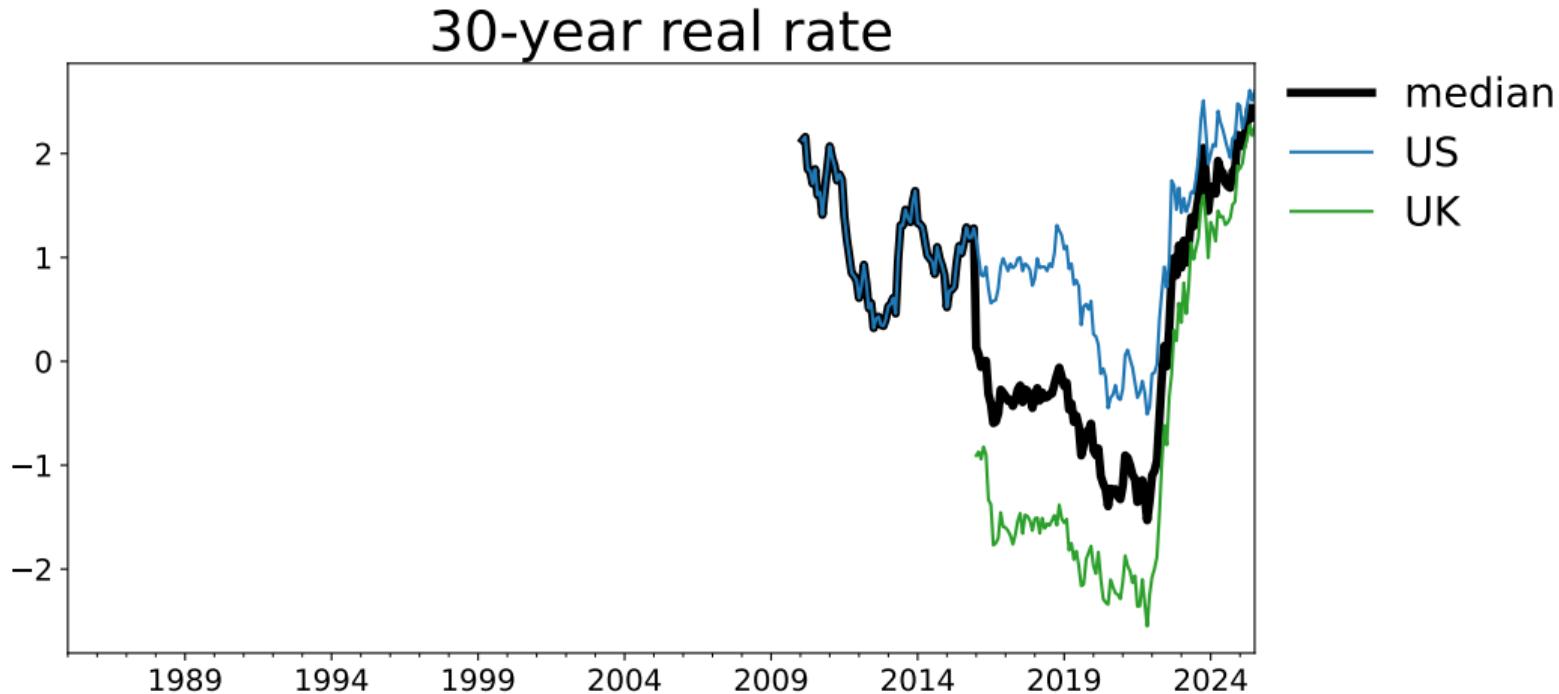
"I'm usually on the more frugal, conservative finance side. My whole life's been budgeting, and we're like, 'Nope, we're going to take that extra, very expensive vacation this year," said Sharon Korinek.

Korinek used to do chief financial officer-type work for private companies but hasn't returned to an office job because she doesn't see the point of it. Her husband, Anton, agrees. He's an economist at the University of Virginia who researches artificial intelligence and has aired his viewed at [Marketplace Tech.](Marketplace Tech.)

The Korineks can fund that extra vacation partly because they're not saving for one very-big-ticket item in the future.

"I've had so many arguments about this. I'm like, 'Our kids aren't going to college,'" Sharon said. "Most people look at us like we're crazy."

Sharon and Anton have two kids, ages 8 and 6. The thought of opening a 529 college savings plan feels absurd to them, considering that they envision a future in which AI will be smarter than most humans.

**Zachary Anglin** @zachanglin · Sep 26, 2022
Have you?

💬 1      ⟲      ♡      ᐧ�|ᐧ|
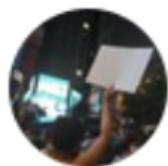
**Kelsey Piper**
@KelseyTuoc

taken out large (>1M) long-term loans? yes

9:12 PM · Sep 26, 2022

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**Cate Hall** ✓
@catehall

In 2017 I was convinced AI timelines were <5 years so I cashed in my 401k and blew away the money and let me tell you this particular form of intellectual consistency is Not Recommended

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**OpenAI**

# Benefits

**For employees**

✓ Health, dental, and vision insurance

✓ Mental healthcare support and services

✓ Commuter benefits

✓ 401(k) with generous matching

✓ Domestic conference budget for each employee

**Existing literature: weak or no relationship between $r$ and $g$** [Rogoff-Rossi-Schmelzing 2024; Lunsford-West 2019; Hamilton et al 2016; Borio et al 2022; ...; Hall 1978]

# Existing literature: weak or no relationship between $r$ and $g$ [Rogoff-Rossi-Schmelzing 2024; Lunsford-West 2019; Hamilton et al 2016; Borio et al 2022; ...; Hall 1978]



Panel A. Real rate $r_t$ per capita GDP growth, ten-year moving averages
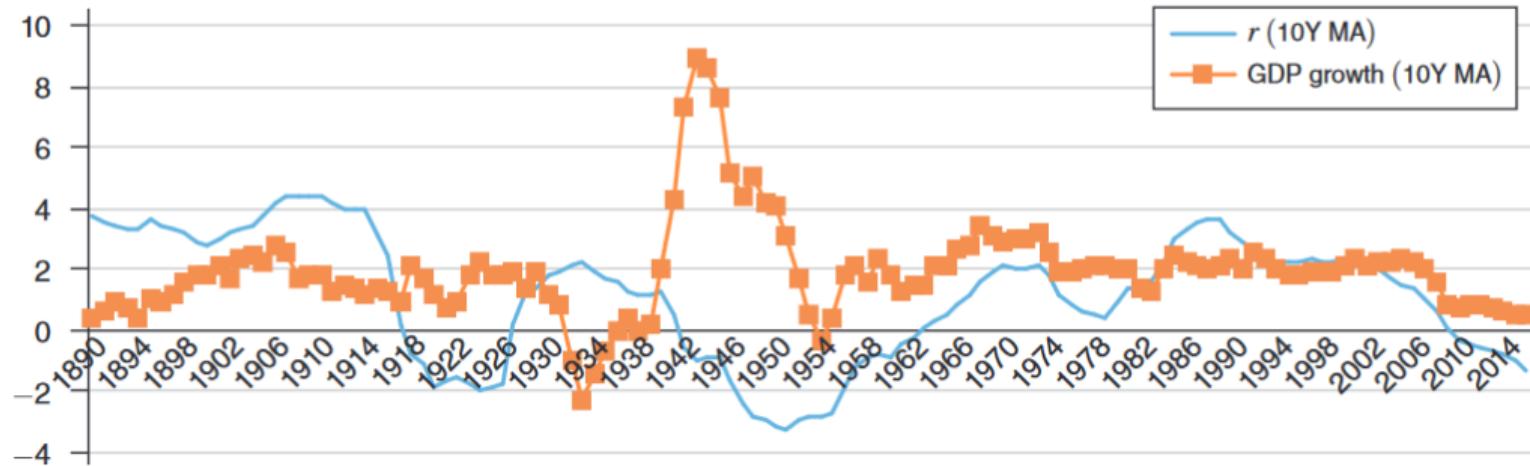
Legend:
— $r$ (10Y MA)
— GDP growth (10Y MA)

# Existing literature: weak or no relationship between _r_ and _g_ [Rogoff-Rossi-Schmelzing 2024; Lunsford-West 2019; Hamilton et al 2016; Borio et al 2022; ...; Hall 1978]

**Goal:** measure *long-term* real interest rates

$$r_t = i_t - \mathbb{E}_t \pi_{t+1}$$
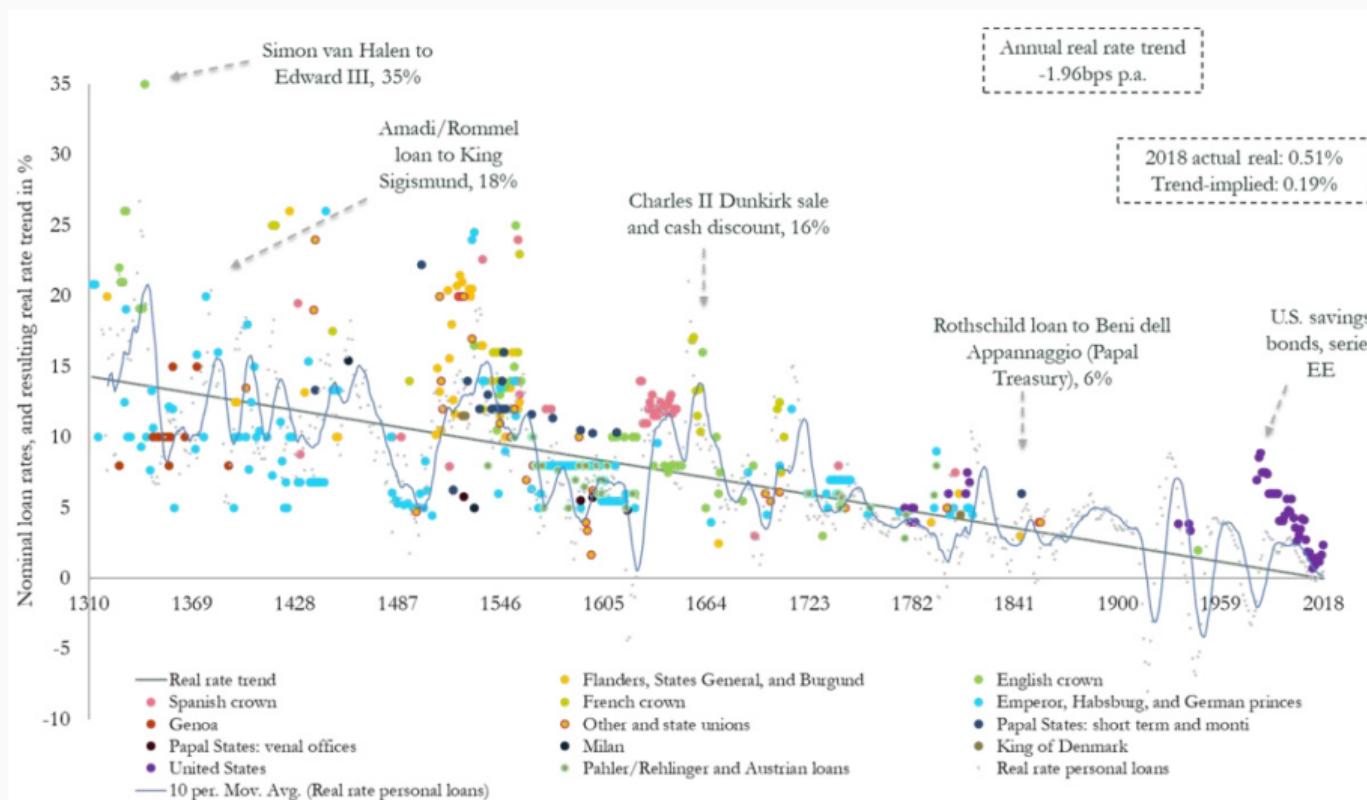
**Goal:** measure *long-term* real interest rates

$$r_t = i_t - \mathbb{E}_t \pi_{t+1}$$

**Inflation expectations:** cross-country survey data

- ▸ 59 countries + up to 35 years of data　　(variation!)
- ▸ 1-to-10-year horizon
- ▸ Source: Consensus Economics

# Challenge 2: distinguishing the short run and long run
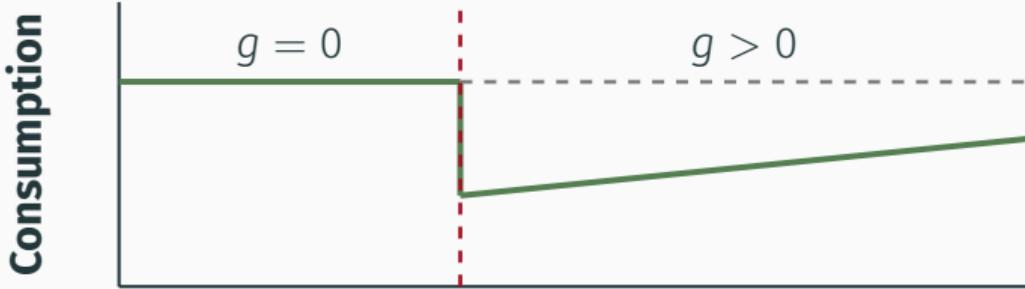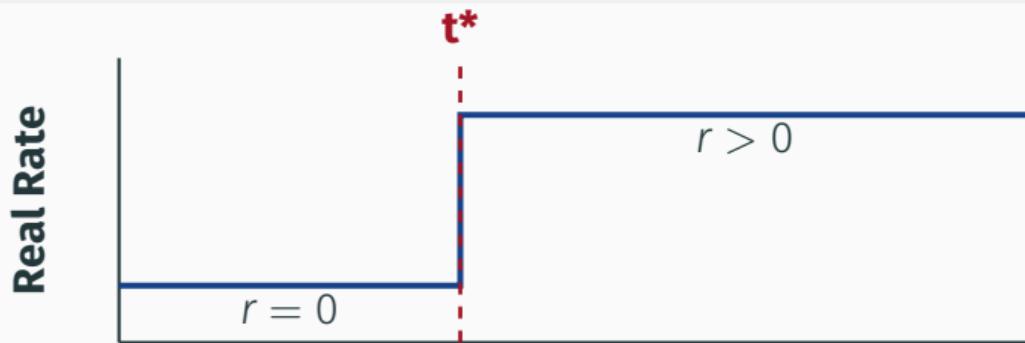
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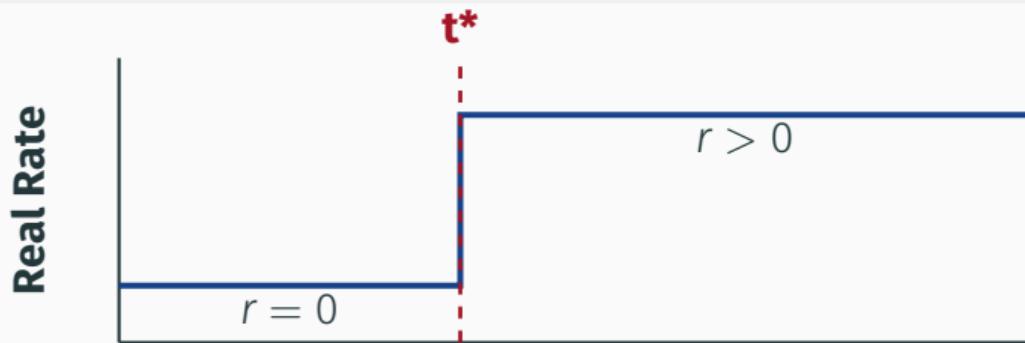


$\implies$ Use *long-term* real interest rates
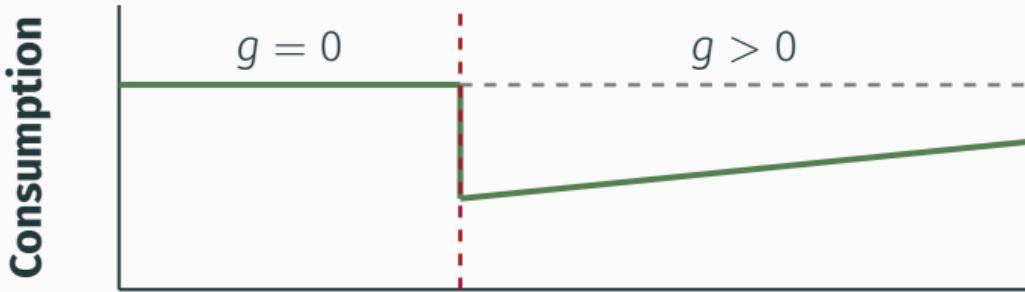
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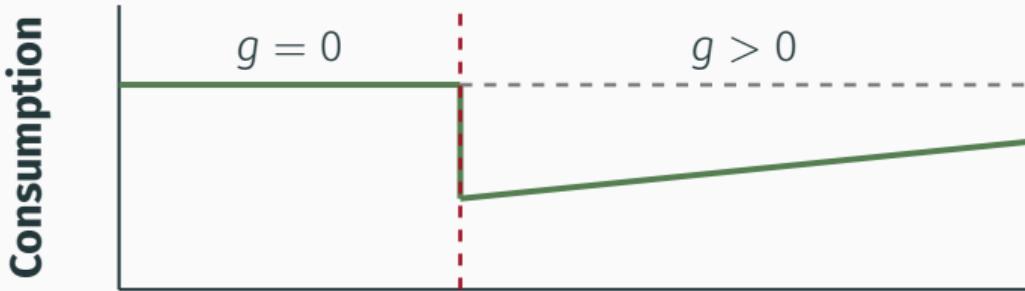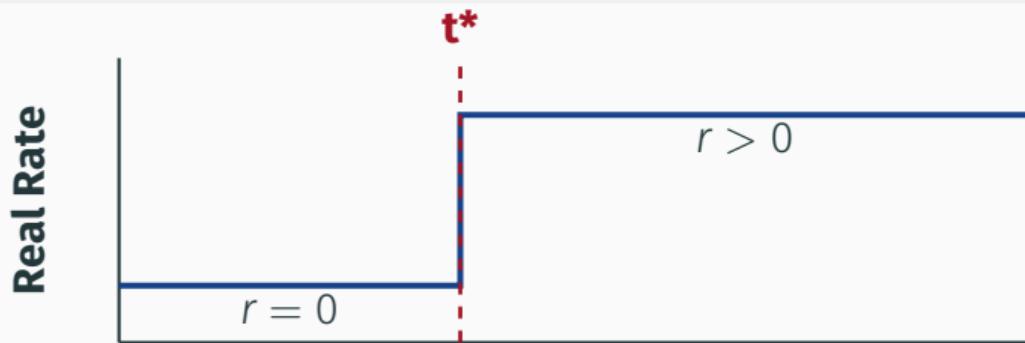


$\Longrightarrow$ Use *long-term* real interest rates

▶ Main analysis: 5y5y

# Expected growth vs. ex ante real rates

Growth expectations vs. real rate
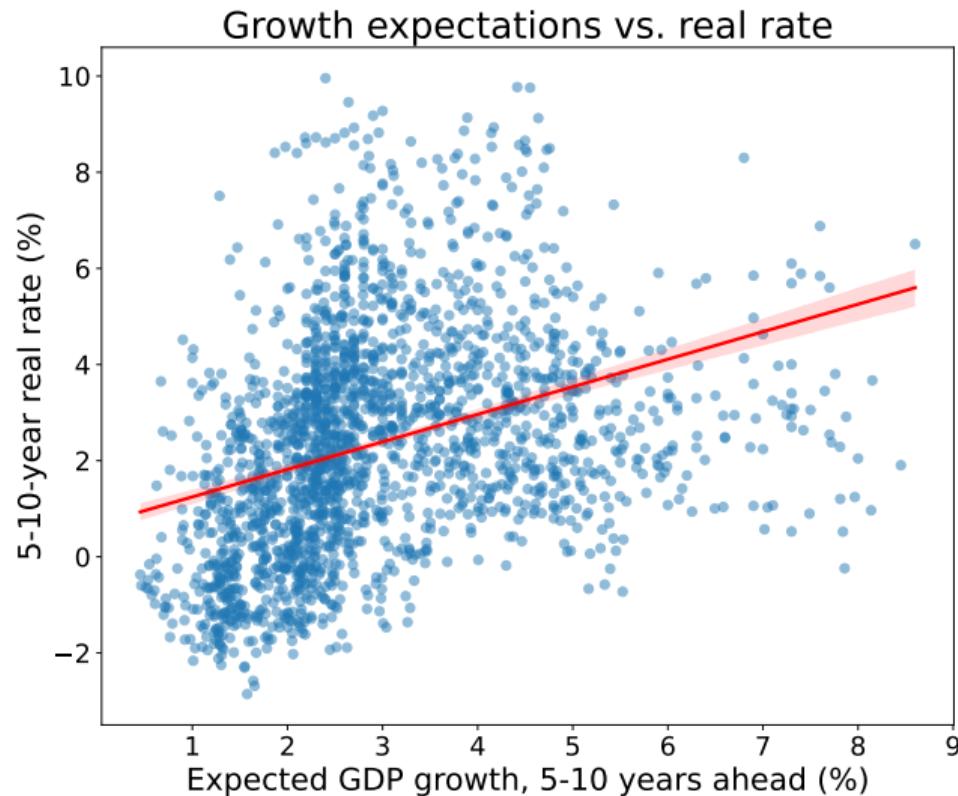
## Expected growth vs. ex ante real rates

**Table 1:** Expected growth vs. real rate

|  | *Dependent variable: 5-10-year real rate* | | | |
|---|---|---|---|---|
|  | (1) | (2) | (3) | (4) |
| 5-10-year GDP growth forecast | 0.71*** | 1.15*** | 1.80*** | 1.36*** |
|  | (0.12) | (0.19) | (0.21) | (0.26) |
| SD(5-10-year GDP growth forecast) |  |  | -0.19 | -0.36* |
|  |  |  | (0.47) | (0.21) |
| 5-year GDP growth forecast |  |  | -1.09*** | -0.59** |
|  |  |  | (0.23) | (0.28) |
| CDS spread |  |  | 0.262** | 0.120** |
|  |  |  | (0.112) | (0.059) |
| Country FE | No | Yes | No | Yes |
| Observations | 3080 | 3080 | 2113 | 2113 |
| Overall $R^2$ | 0.16 | 0.10 | 0.39 | 0.34 |
| Within $R^2$ |  | 0.23 |  | 0.22 |

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# Expected growth vs. ex ante real rates

Demeaned growth expectations vs. demeaned real rate
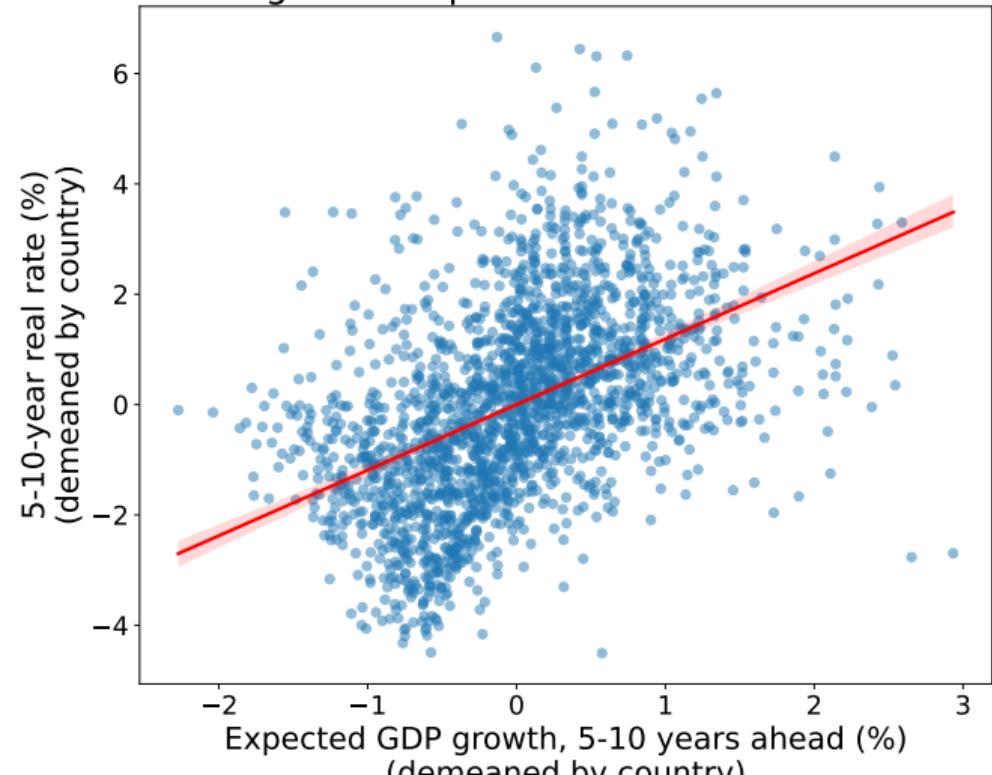
Country averages: Growth expectations vs. real rate
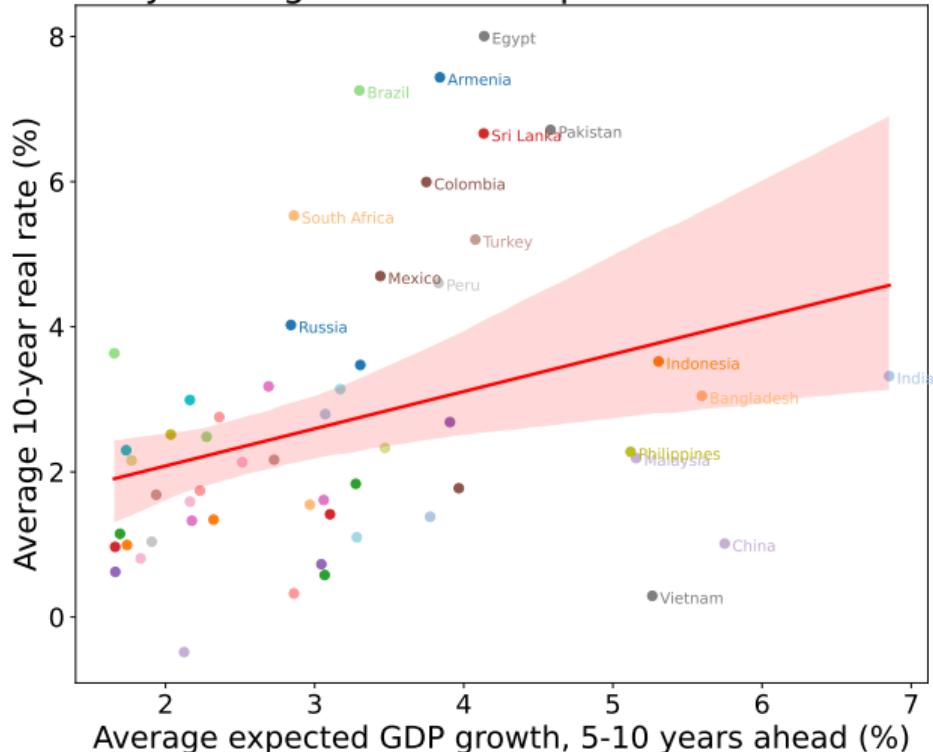
Five-year changes:
Growth expectations vs. real rate

**Taking the results extremely seriously**

## Taking the results extremely seriously

Baseline regression result
(no controls, no FE):

$$g_{5y5y} = \frac{1}{0.71} \cdot r_{5y5y} - 0.03$$

US 5y5y real rate as of Nov 30:

2.33%

Projected 5y5y growth rate:

$= 3.25\%$
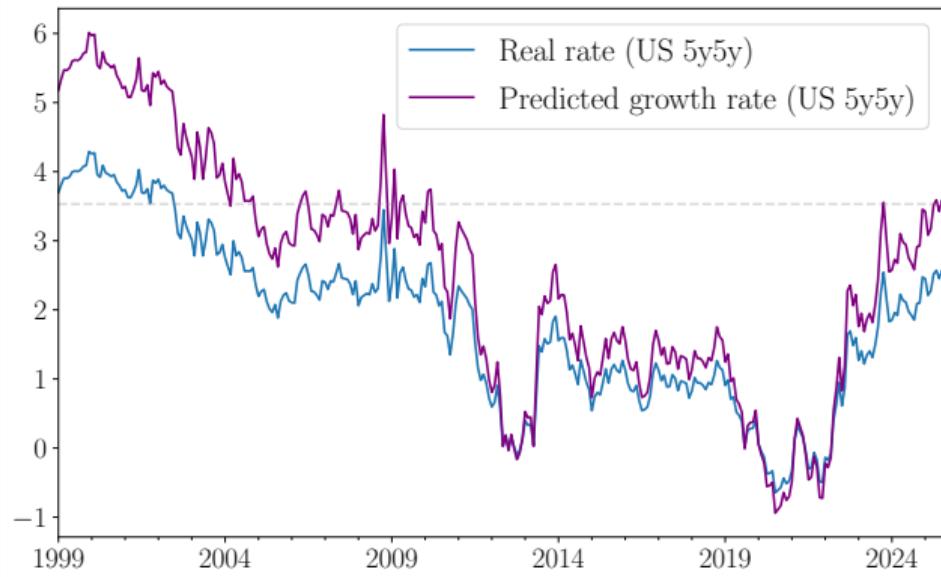
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   - ▸ New products [Trammell (2024)]
   - ▸ Habit formation

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Bad arguments:

(i) "Want to invest more – to have a shot at controlling the lightcone". Maresca 2025: you want to save more, but this still pushes up *r*

(ii) "High expected returns": *movement along supply curve* vs. *shift* in supply curve
  - · Also distinguish between high risk-free rate (discussion here) versus high *risk premium* (not discussed here)

## Real rates and mortality risk

**Challenge:** measuring existential risk over time

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- ► $\implies$ Test mechanism
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5. Cold War evidence (sort of)

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$$P = \frac{D}{r - g}$$

$$= \frac{D}{(\rho + \frac{1}{\sigma} \cdot g) - g}$$

$$= \frac{D}{\rho + (\frac{1}{\sigma} - 1) \cdot g}$$

*r* affects all assets

# Other asset prices: stocks

Given our estimate the $\sigma < 1$, **rising AI stock valuations** are consistent with **market expecting AI to be profitable**, but **not transformative**
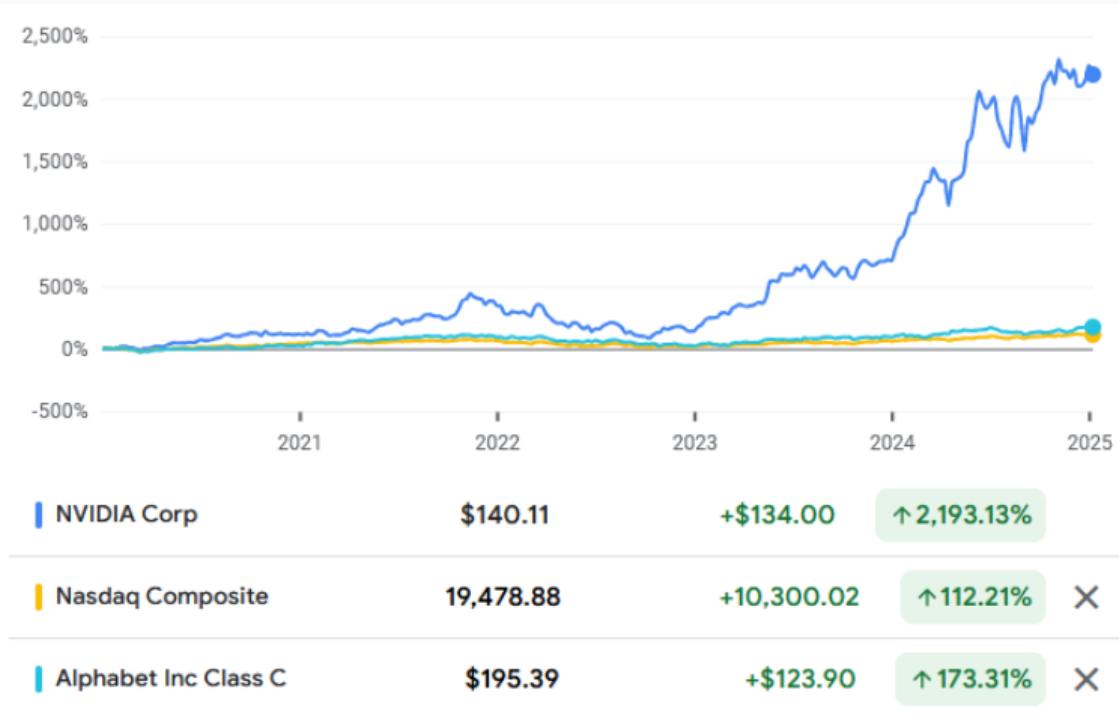


| | | | |
|---|---|---|---|
| ▌NVIDIA Corp | $140.11 | +$134.00 | ↑2,193.13% |
| ▌Nasdaq Composite | 19,478.88 | +10,300.02 | ↑112.21% ✕ |
| ▌Alphabet Inc Class C | $195.39 | +$123.90 | ↑173.31% ✕ |

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## Conclusion: Two possibilities

**1. Markets are are efficient information aggregators**

**2. Markets are wrong**

- ▶ Trade opportunity? ("Get rich or die trying")
- ▶ Opportunity to borrow cheaply? ("*Im*patient philanthropy")

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Contribution:

1. **AI safety:** *outside view* evidence on AI timelines
2. **Mainline economics:** fundamental question about determinants of real interest rates

# 1. Surveys

- ▶ Grace et al. (2018) survey of AI researchers: "when unaided machines can accomplish every task better and more cheaply than human workers"
  - Median: **2061**
- ▶ Grace et al. (2022):
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- ► Grace et al. (2024):
  - Median: **2047**
- ► Metaculus forecasting platform
  - Median: **2031**

Korinek et al. (2022) survey of economists: **2070-2130+**



## HLMI PREDICTIONS: ECONOMISTS & AI RESEARCHERS
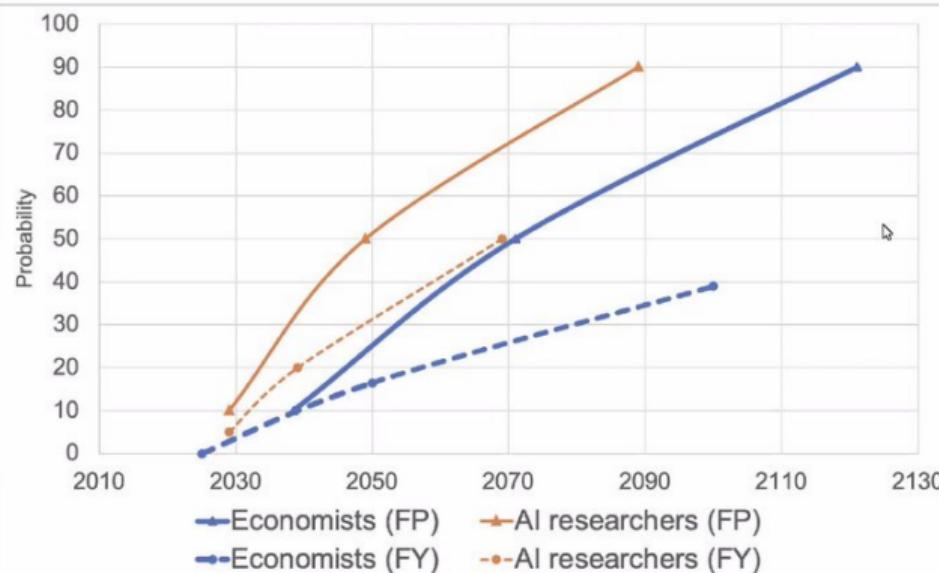
**Economists ascribe a median 10% probability to HLMI never being developed.**

FP = fixed probability (shown probability, asked for years)

FY = fixed year (shown year, asked for likelihood)

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## 2. Models / trend extrapolation

**Exponential Growth of Computing**
Twentieth through twenty first century

*Logarithmic Plot*

All Human Brains

One Human Brain

One Mouse Brain

One Insect Brain

Calculations per Second per $1,000
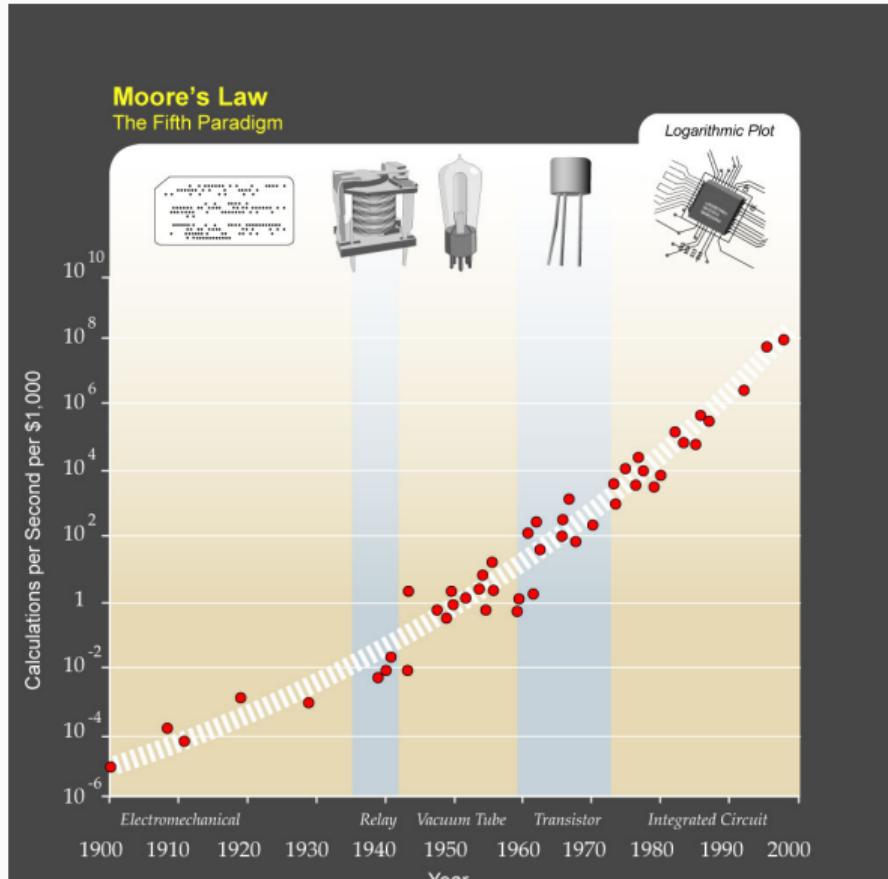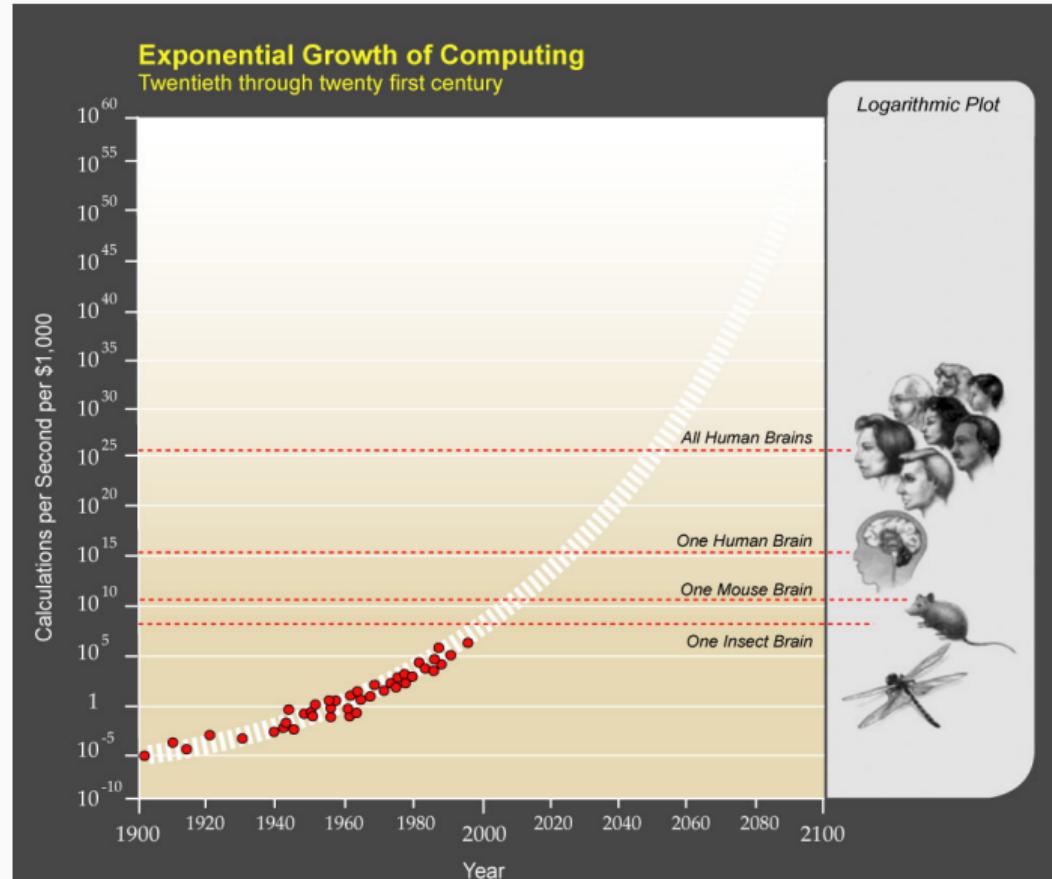
## Deep and steep

Computing power used in training AI systems

Days spent calculating at one petaflop per second*, log scale

By fundamentals

- Language
- Speech
- Vision
- Games
- Other

AlphaGo Zero becomes its own teacher of the game Go

3.4-month doubling

AlexNet, image classification with deep convolutional neural networks

Two-year doubling (Moore's Law)

← First era →   → Modern era

Perceptron, a simple artificial neural network

| 100 |
| 10 |
| 1 |
| 0.1 |
| 0.01 |
| 0.001 |
| 0.0001 |
| 0.00001 |
| 0.000001 |
| 0.0000001 |

1960   70   80   90   2000   10   20

## 2. Models / trend extrapolation
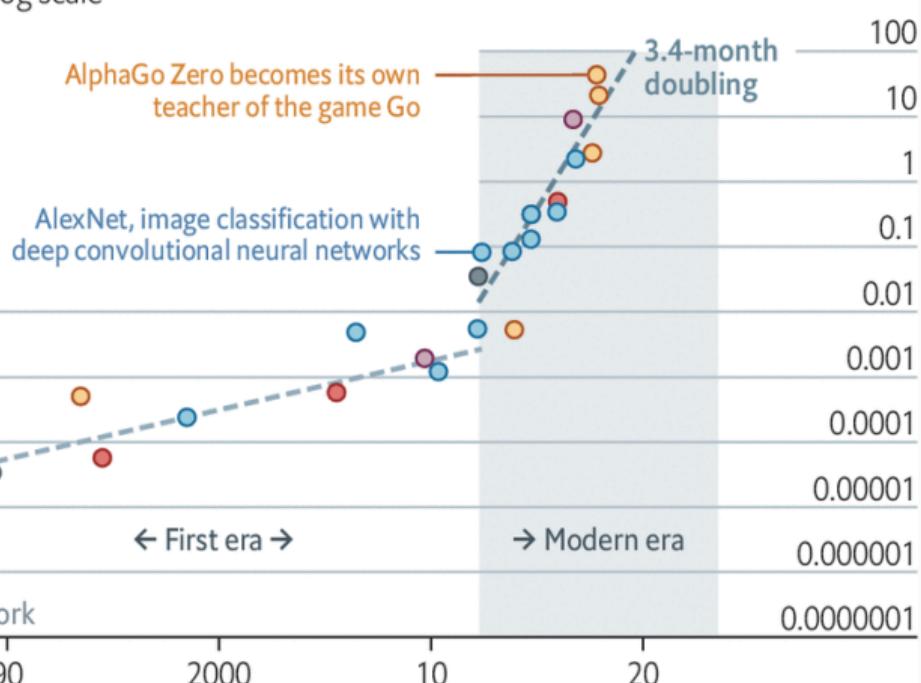
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- **Cotra (2020):** 2050
- **Cotra (2022):** 2040
- **Davidson (2023):** 2043
- **Epoch (2022):** 2046

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# Bio anchors (Epoch version)
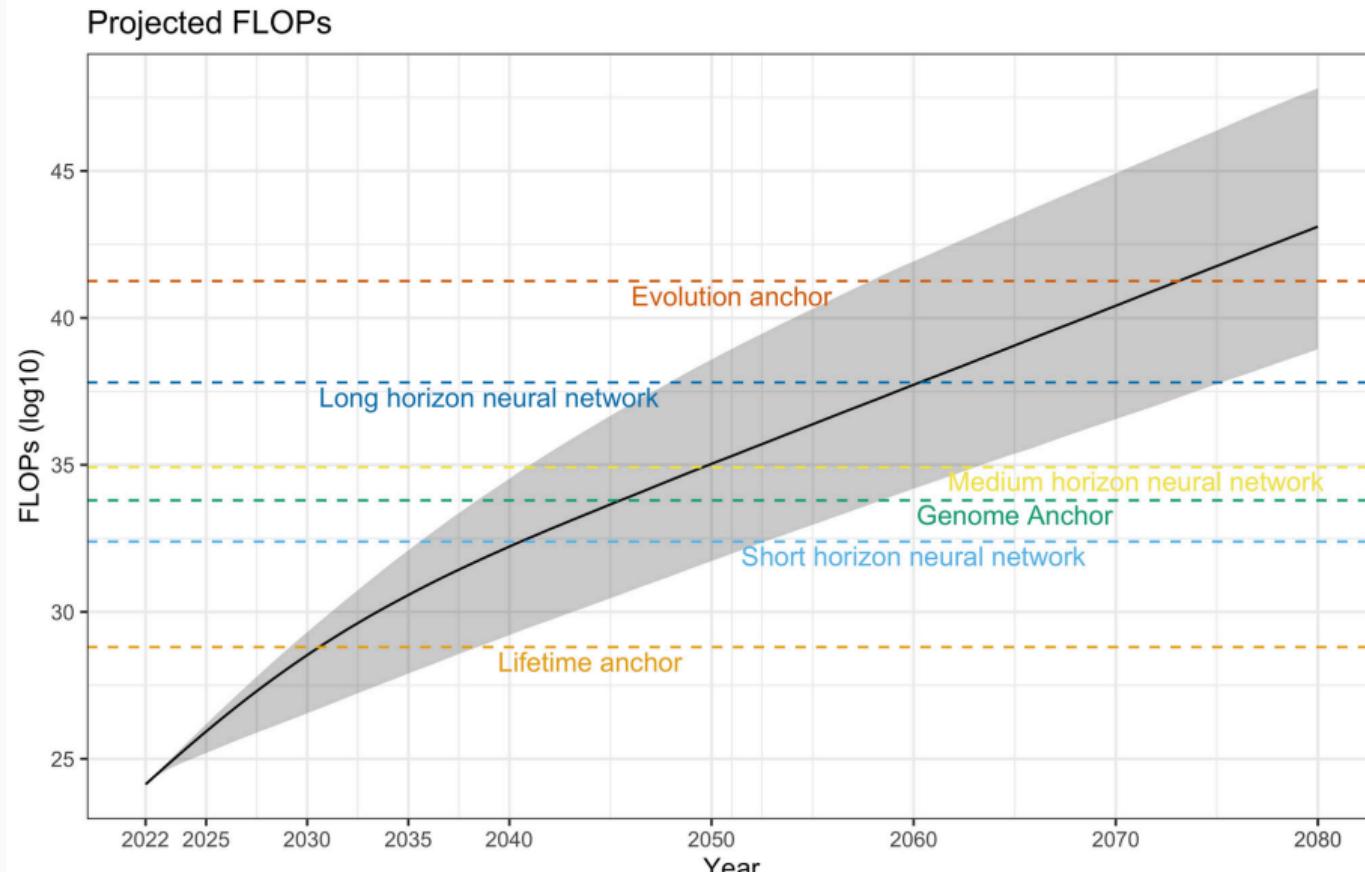
**Prices aggregate dispersed information (Hayek 1945); financial market prices especially so (Fama, etc)**

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▸ Alchian and the hydrogen bomb



Change in Stock Prices: March 1954
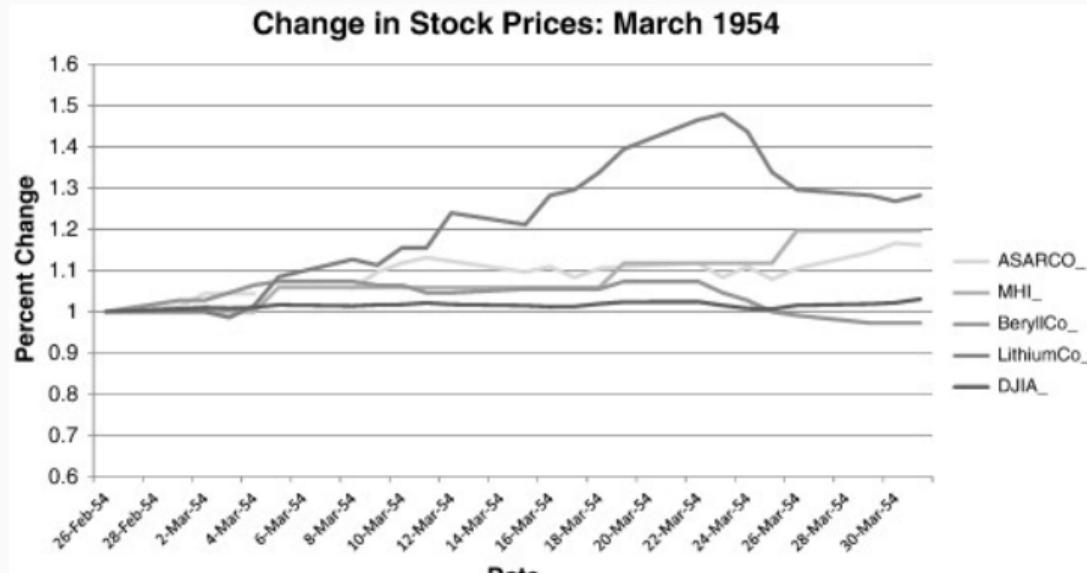
**Prices aggregate dispersed information (Hayek 1945); financial market prices especially so (Fama, etc)**

- ▶ Alchian and the hydrogen bomb
- ▶ Space shuttle Columbia disaster; election markets; inflation breakevens; …



Change in Stock Prices: March 1954

When will it be feasible to automate all tasks or occupations?

# Inflation-linked bonds and *realized* growth
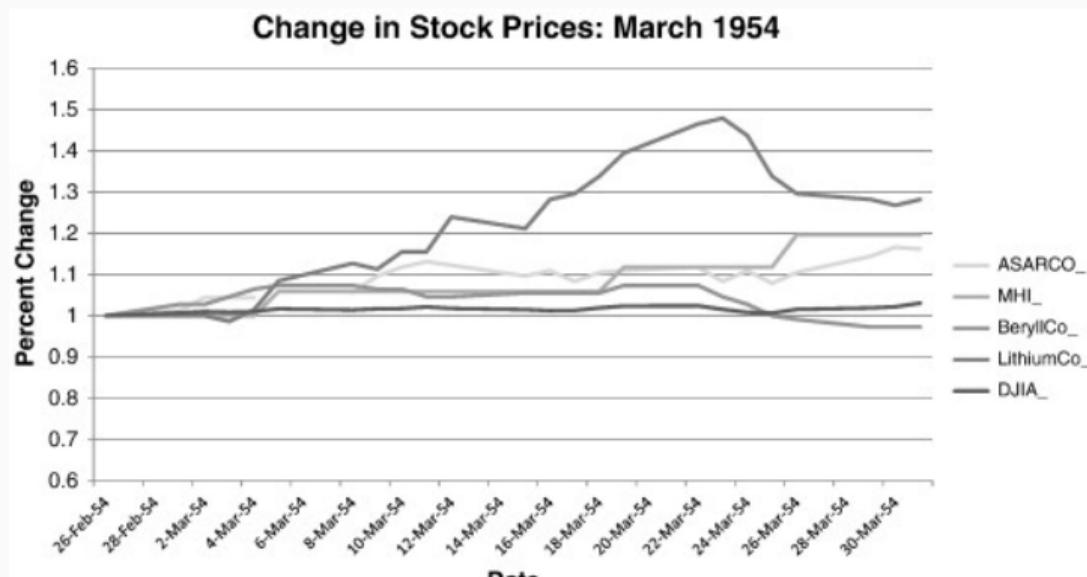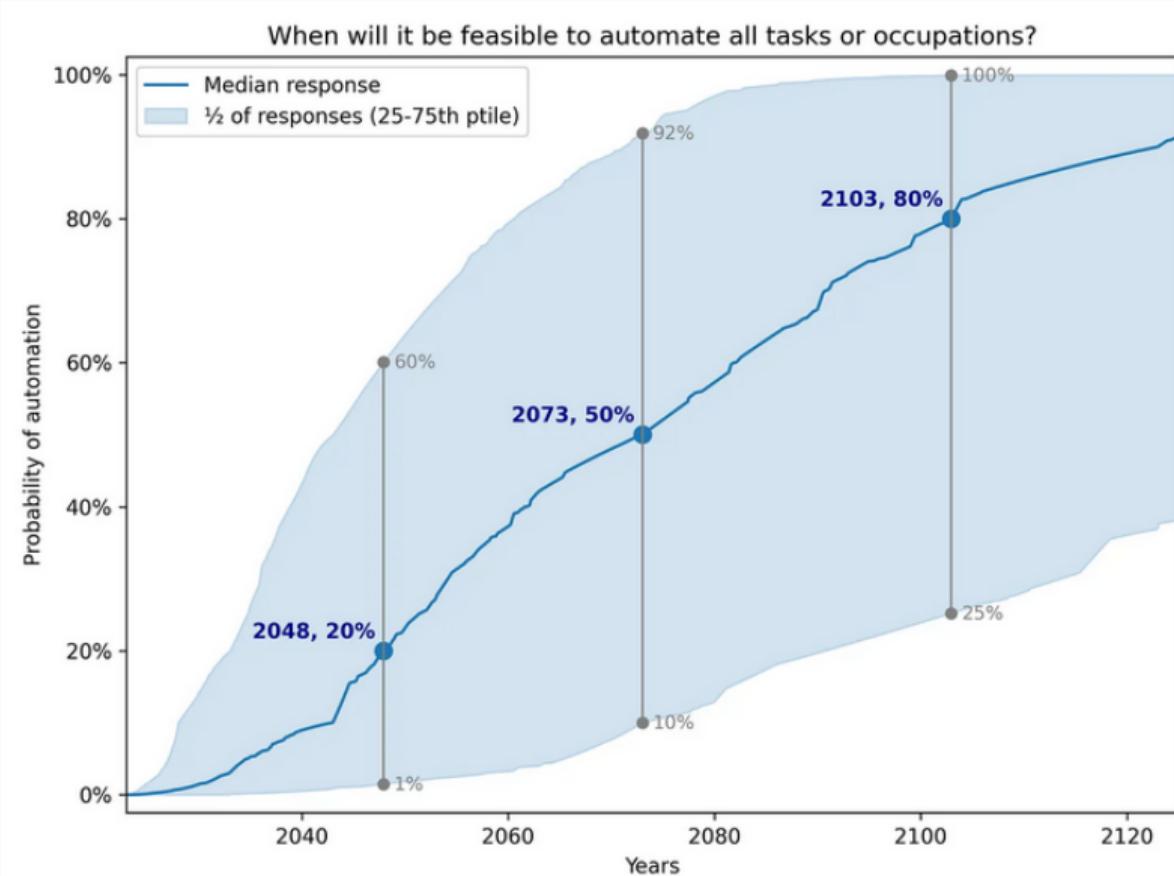
## Real rate vs. future real GDP growth



10-year horizon  15-year horizon  20-year horizon

Real GDP growth over horizon

Real rate over horizon

● US    ● UK    ● Australia    ● Canada    - - - OLS

32
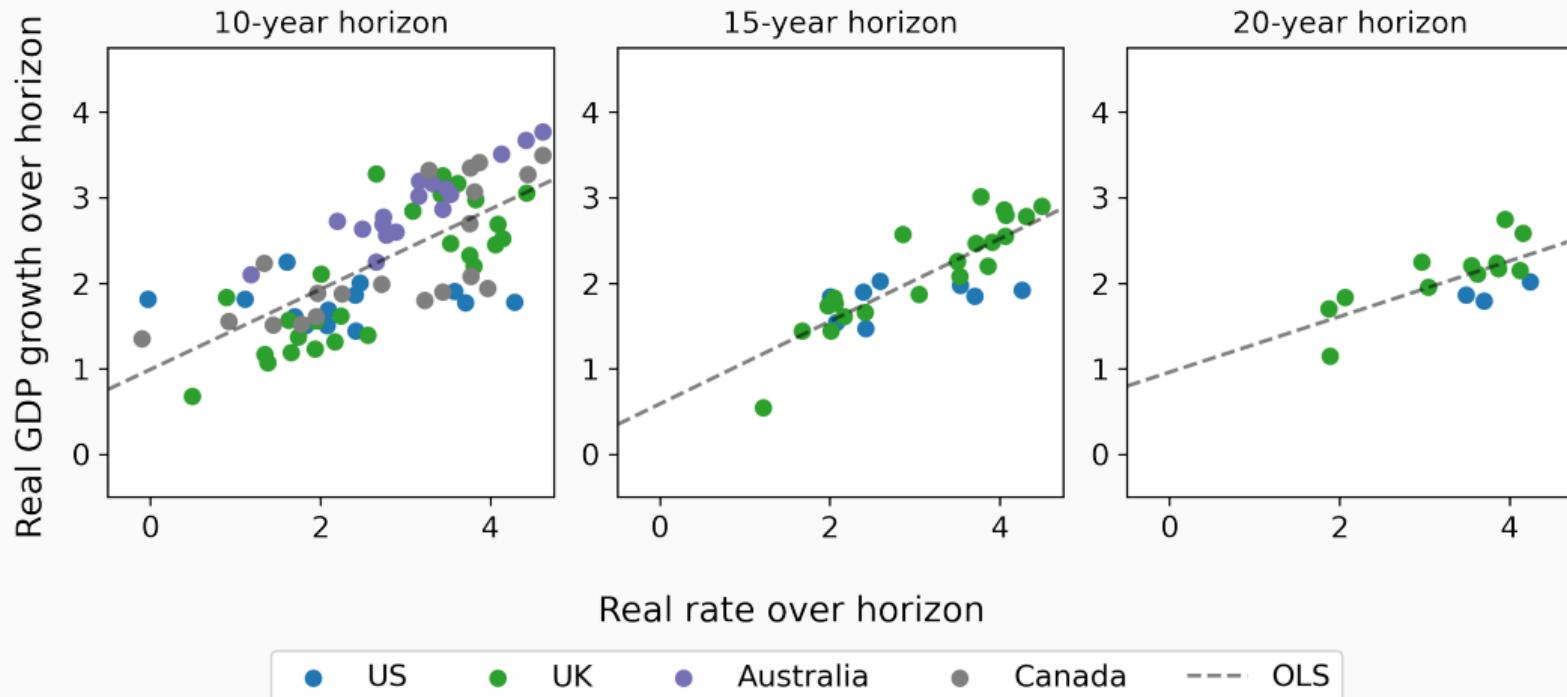
Growth Expectations vs. realized growth
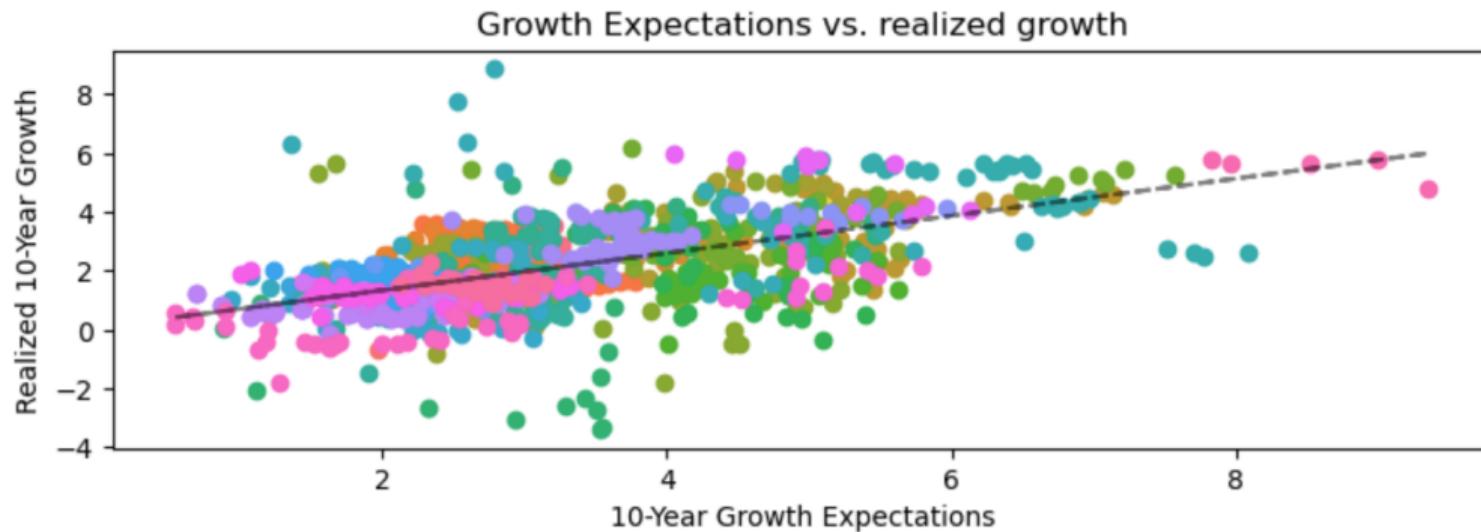
## Robustness

**1. Preferences:** recursive utility (Flynn, Schmidt, and Toda 2023) and under internal habit formation (Bhamra and Uppal 2014; Hamilton et al. 2016; Dennis 2009)

**2. Incomplete markets:** Werning (2015)

**3. Belief heterogeneity:** Buraschi and Whelan (2022), Molavi et al (2025)

## Phase diagram analysis



**NCG:**
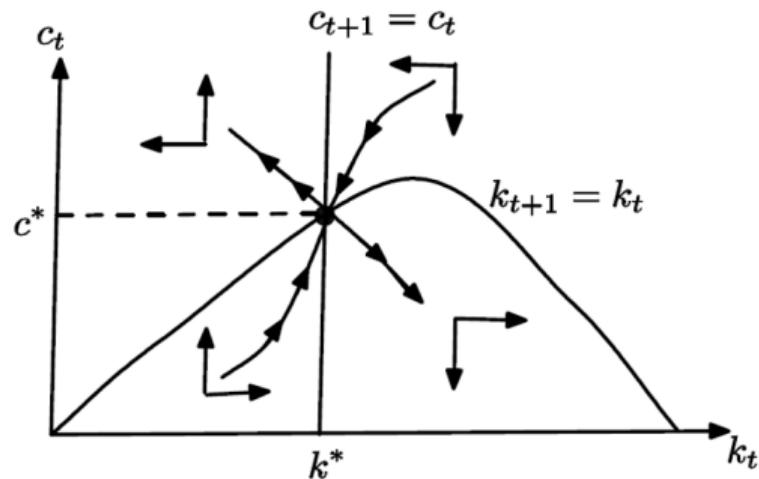
- Neoclassical growth

## Phase diagram analysis



**Permanent productivity shock today:**
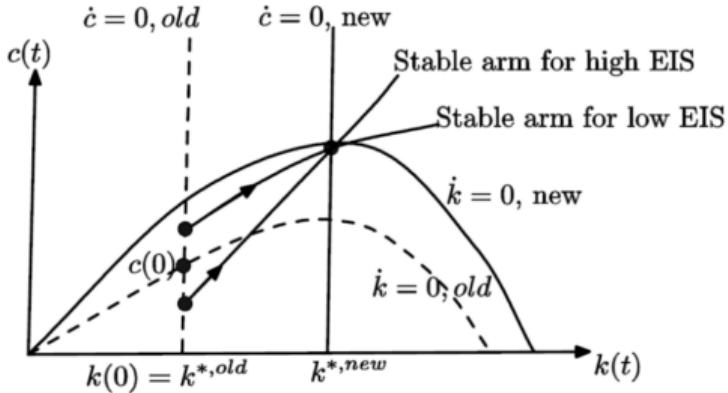
- Consumption can jump up, jump down, or be constant; but then increases to new SS
- Depends on EIS i.e. income vs. substitution effects: if EIS>1, then more willing to trade consumption tomorrow for consumption today, i.e. substitution outweighs income effect and jumps down; vice-versa if EIS<1

## Phase diagram analysis

**Transitory TFP shock:**

$A' > A$ for $t \in [0, \hat{t}]$, then revert to $A$
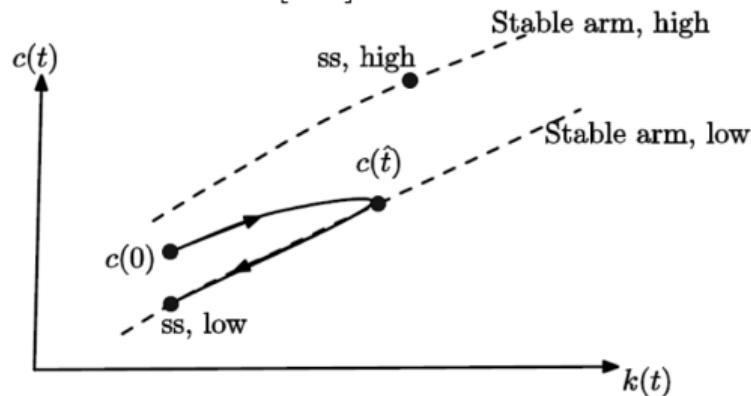


- Between $[0, \hat{t}]$, follow the dynamics of the new system
- At time $\hat{t}$, need to land on original stable arm
- Consumption jumps up; then could increase, decrease, or stay constant; until $\hat{t}$ when it decreases back to original SS. Thus, a cusp in the time-path for *c*

**News about future productivity shock:**
$A' > A$ at $t = \hat{t}$; but news received at $t = 0$



Permanent productivity shock today:
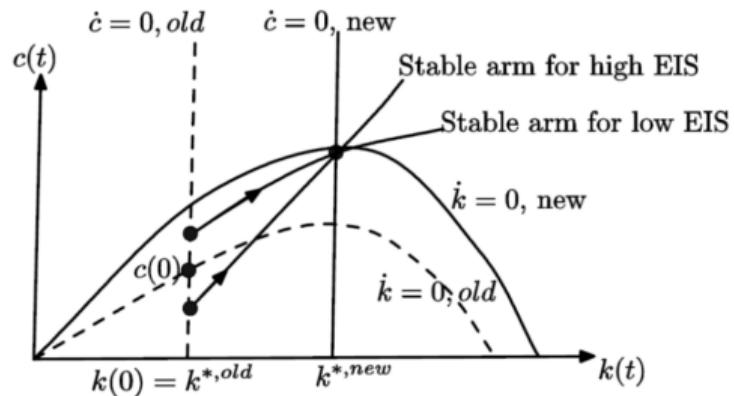
- From $[0, \hat{t}]$, you follow original dynamics
- At $\hat{t}$, you have to be on new saddle path
- Need to jump between old and new saddle path, otherwise you explode

# Andrews and Farboodi (2025): event study around LLM releases



Mean change across events

Basis points (bp) vs. Relative time in trading days (0 = event day)

Series
- 1 Year Treasuries
- 5 Year Treasuries
- 10 Year Treasuries
- 20 Year Treasuries
- 30 Year Treasuries

10y real rate around model releases ("frontier" model releases)
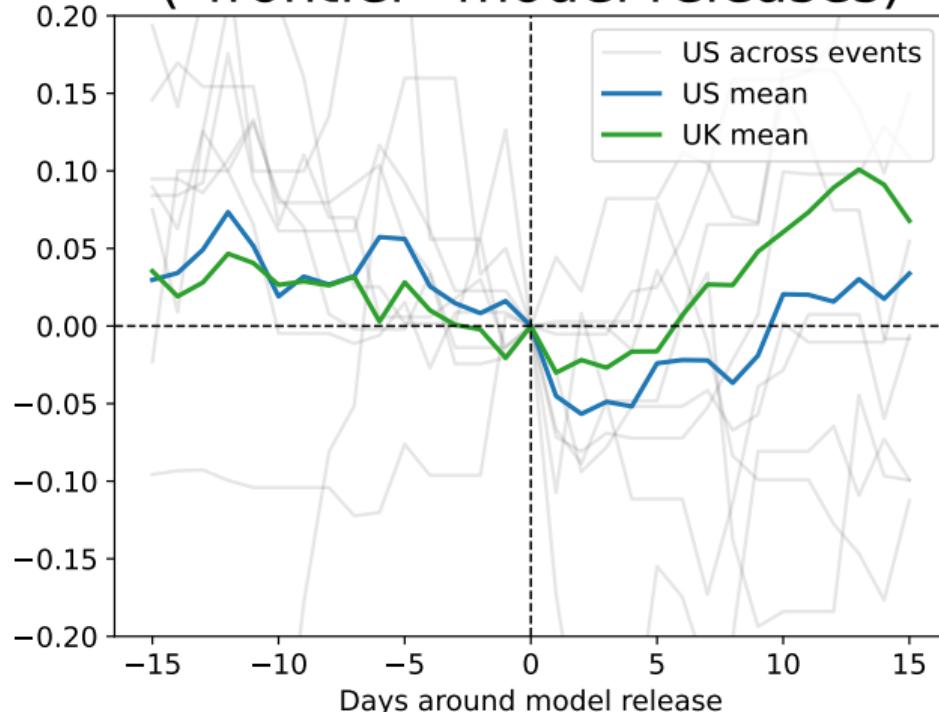
Median equities around model releases ("frontier" model dates)
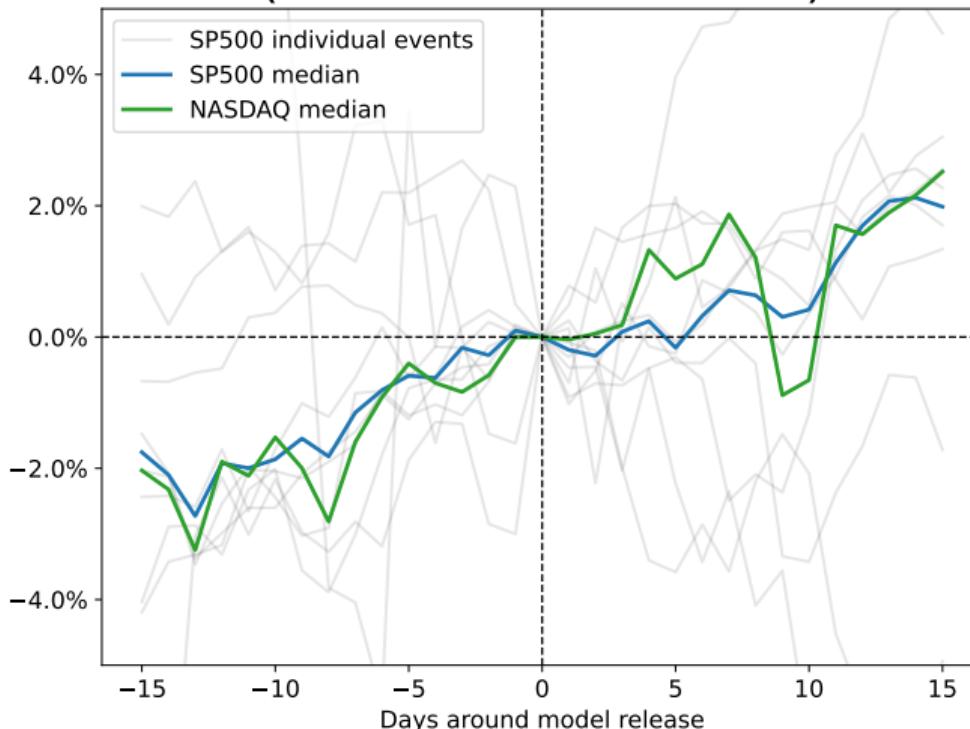
**The world's simplest structural model**

- ▶ Take the (nonlinear) Euler equation
- ▶ Plug in smoothed **Cotra (2022) probabilities for transformative AI over the next 30 years:** a 2% yearly chance until 2030, a 3% yearly chance through 2036, and a 4% yearly chance through 2052
- ▶ We use the **FTX Future Fund's median estimate of 15% for the probability that AI is unaligned** conditional on the development of transformative AI.
- ▶ Arrival of aligned AI: 30% annual consumption growth.
- ▶ Extinction: utility goes to zero.
- ▶ In absence of TAI: 1.8% growth rate
- ▶ Calibrate the pure rate of subjective time preference to 0.01
- ▶ Calibrate EIS = 1

Play with the model yourself! here

## Euler equation model: baseline results

By default, $g = 1.8\%$ per year. Every year, some probability (based on Cotra) TAI developed. If developed, 15% probability world ends + 85% chance $g = 30\%$

**Baseline Euler:** $r = 2.8\%$

**Euler + stochastic TAI:** $r_{0,30} = 5.9\%$

# Euler model: varying alignment risk



**Real rate model: varying alignment risk**

Legend:
- Baseline real rate (no transformative AI)
- Real rate (with transformative AI)

X-axis: P( misalignment | transformative AI )
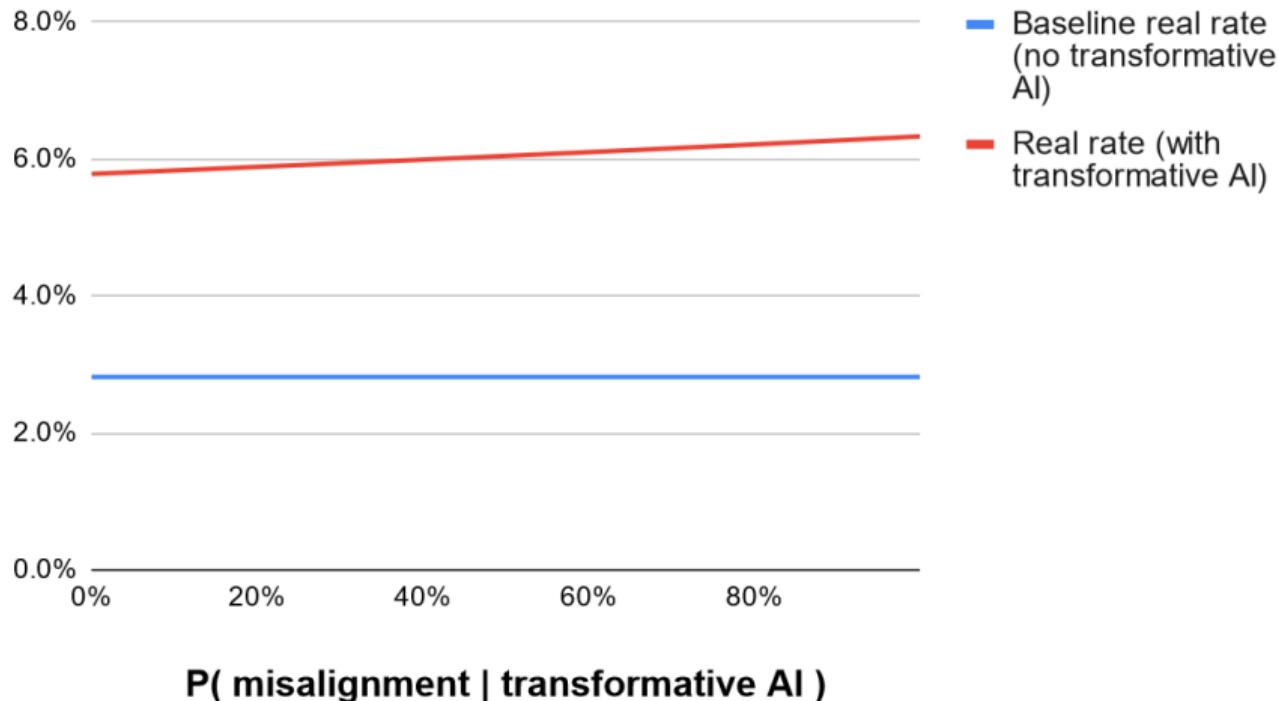
# Euler model: varying timelines



**Real rate model: varying timelines**

Legend:
- Baseline real rate (no transformative AI)
- Real rate (with transformative AI)
- FTX lower bound
- FTX median
- FTX upper bound / Cotra

X-axis: Pr( transformative AI by 2043 )
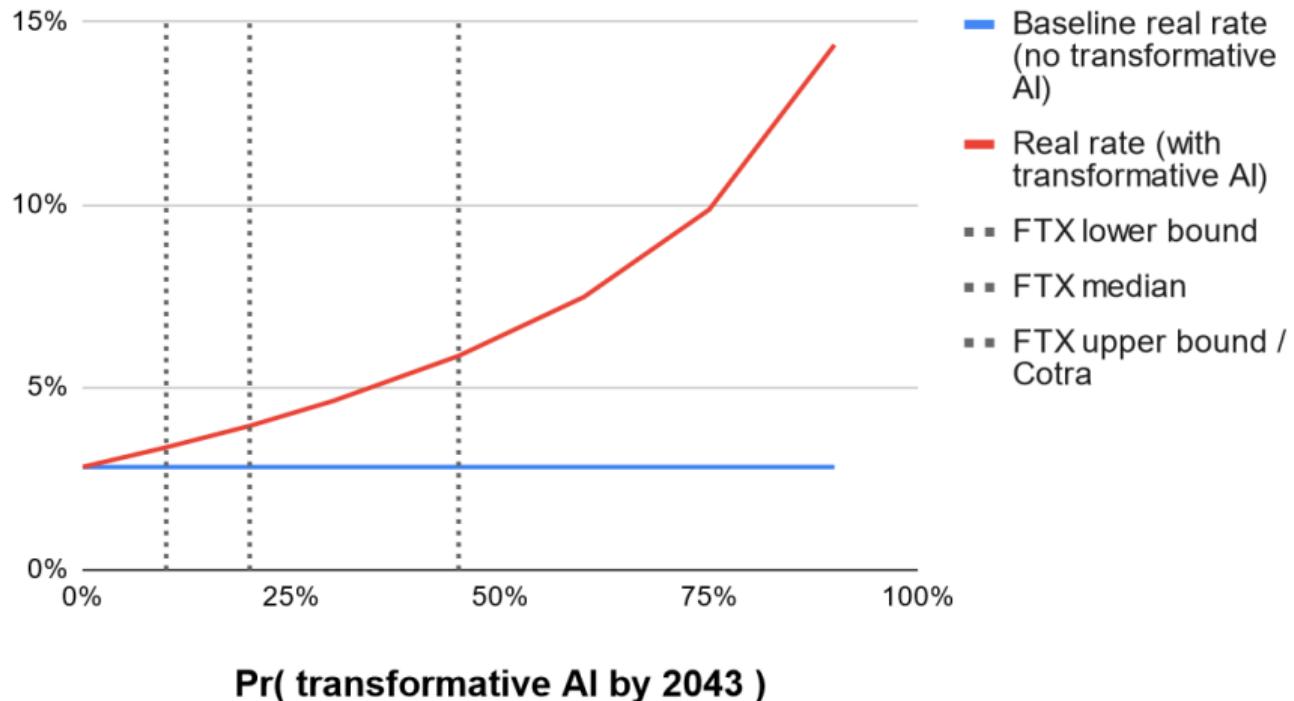
## Euler model: markets are decisively rejecting AI 2027

1. Five year timelines: With a 50% probability of transformative AI by 2027, and the same yearly probability thereafter, the model predicts 13.0pp higher 30-year real rates today!

2. Ten year timelines: With a 50% probability of transformative AI by 2032, and the same yearly probability thereafter, the model predicts 6.5pp higher 30-year real rates today.