



Artificial Intelligence and Economic Growth

Chad Jones
Stanford GSB

October 2025

What are the implications of A.I. for economic growth?

- Build some growth models with A.I.
 - A.I. helps to make goods
 - A.I. helps to make ideas
- Implications
 - Long-run growth
 - Share of GDP paid to labor vs capital
- Catastrophic risks from A.I.?

Talk based on material from several papers

- Aghion, B. Jones, and C. Jones (2019) “Artificial Intelligence and Economic Growth”
- Jones (2024 AER Insights) “The A.I. Dilemma: Growth versus Existential Risk”
- Jones (2025) “How much should we spend to reduce A.I.’s existential risk?”
- Jones and Tonetti (2025, in progress) “Past Automation and the Future of A.I.”

Two Main Themes (Aghion, B. Jones, and C. Jones, 2019)

- A.I. modeled as a continuation of automation
 - Automation = replace labor in particular tasks with machines and algorithms
 - *Past*: textile looms, steam engines, electric power, computers
 - *Future*: driverless cars, paralegals, pathologists, maybe researchers, maybe everyone?
- A.I. may be limited by Baumol's cost disease $\Rightarrow$ bottlenecks
 - *Baumol*: growth constrained not by what we do well but rather by what is essential and yet hard to improve



The Zeira 1998 Model

Simple Model of Automation (Zeira 1998)

- Production uses n tasks/goods:

$$Y = AX_1^{\alpha_1} X_2^{\alpha_2} \cdot \dots \cdot X_n^{\alpha_n},$$

where $\sum_{i=1}^n \alpha_i = 1$ and

$$X_{it} = \begin{cases} L_{it} & \text{if not automated} \\ K_{it} & \text{if automated} \end{cases}$$

- Substituting gives

$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}$$

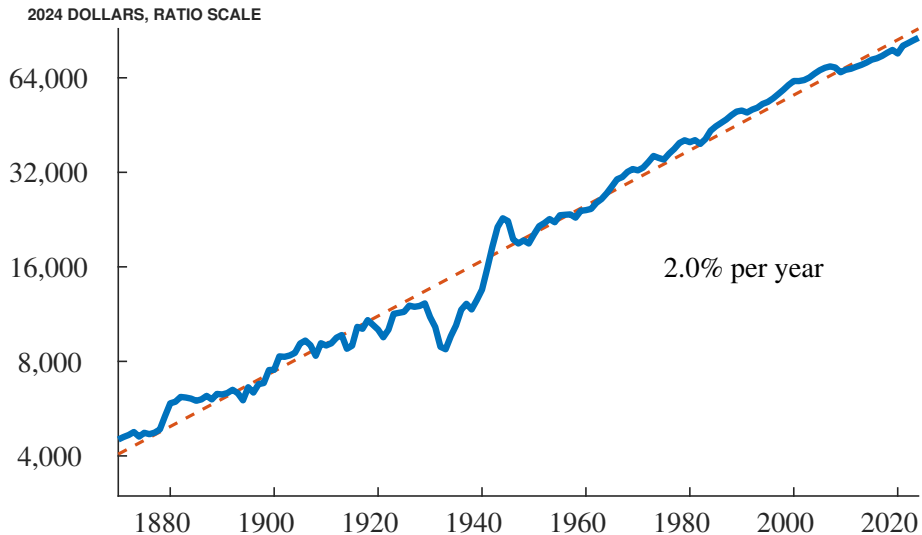
$$Y_t = A_t K_t^\alpha L_t^{1-\alpha}$$

- Comments:
 - α reflects the *fraction of tasks that are automated*
 - Embed in neoclassical growth model $\Rightarrow$

$$g_y = \frac{g_A}{1-\alpha} \quad \text{where} \quad y_t \equiv Y_t/L_t$$

- Automation: $\uparrow \alpha$ raises both capital share and LR growth
 - Hard to reconcile with 20th century
 - Substantial automation but stable growth and capital shares

Average income per person in the U.S.



Recent papers

- Acemoglu and Restrepo (2017, 2018, 2019, 2020, 2021, 2022, 2023)
 - Foundational work in this literature
 - Old tasks are gradually automated as new (labor) tasks are created
 - Fraction automated can then be steady
 - Rich framework, with endogenous innovation and automation
 - Acemoglu-Restrepo (2022 ECMA): Rising automation can explain 60% of changes in the U.S. wage distribution since 1980
- Hémous and Olson (2016, 2025)
- B. Jones and Liu (2024)



Automation and Baumol's Cost Disease

AJJ Economic Environment

Final good $Y_t = \left(\int_0^1 y_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$ where $\sigma < 1$ (Baumol effect)

Tasks $y_{it} = K_{it} + L_{it} = \begin{cases} K_{it} & \text{if automated } i \in [0, \beta_t] \\ L_{it} & \text{if not automated } i \in [\beta_t, 1] \end{cases}$

Capital accumulation $\dot{K}_t = I_t - \delta K_t$

Resource constraint (K) $\int_0^1 K_{it} di = K_t$

Resource constraint (L) $\int_0^1 L_{it} di = L$

Resource constraint (Y) $Y_t = C_t + I_t$

Allocation $I = \bar{s}_K Y$

AJJ Economic Environment

Complements

Final good $Y_t = \left(\int_0^1 y_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$ where $\sigma < 1$ (Baumol effect)

Tasks $y_{it} = K_{it} + L_{it} = \begin{cases} K_{it} & \text{if automated } i \in [0, \beta_t] \\ L_{it} & \text{if not automated } i \in [\beta_t, 1] \end{cases}$

Substitutes

Capital accumulation $\dot{K}_t = I_t - \delta K_t$

Resource constraint (K) $\int_0^1 K_{it} di = K_t$

Resource constraint (L) $\int_0^1 L_{it} di = L$

Resource constraint (Y) $Y_t = C_t + I_t$

Allocation $I = \bar{s}_K Y$

Automation and growth

- Combining equations

$$Y_t = \left[\beta_t \left(\frac{K_t}{\beta_t} \right)^{\frac{\sigma-1}{\sigma}} + (1 - \beta_t) \left(\frac{L}{1 - \beta_t} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

- How β interacts with K : two effects
 - β : what fraction of tasks have been automated
 - β : Dilution as $K/\beta \Rightarrow K$ spread over more tasks
- Same for labor: $L/(1 - \beta_t)$ means given L concentrated on fewer tasks, raising “effective labor”

Rewriting in classic CES form

- Collecting the β terms into factor-augmenting form:

$$Y_t = F(B_t K_t, A_t L_t)$$

where

$$B_t = \left(\frac{1}{\beta_t} \right)^{\frac{1}{1-\sigma}} \quad \text{and} \quad A_t = \left(\frac{1}{1-\beta_t} \right)^{\frac{1}{1-\sigma}}$$

- Effect of automation: $\uparrow \beta_t \Rightarrow \downarrow B_t$ and $\uparrow A_t$

Intuition: dilution effects just get magnified since $\sigma < 1$

Automation

- Suppose a constant fraction of non-automated tasks get automated every period:

$$\dot{\beta}_t = \theta(1 - \beta_t)$$

$$\Rightarrow \beta_t \rightarrow 1$$

- What happens to $1 - \beta_t =: m_t$?

$$\frac{\dot{m}_t}{m_t} = -\theta$$

The fraction of labor-tasks falls at a constant exponential rate

Putting it all together

$$Y_t = F(B_t K_t, A_t L_t) \text{ where } B_t = \left(\frac{1}{\beta_t} \right)^{\frac{1}{1-\sigma}} \text{ and } A_t = \left(\frac{1}{1-\beta_t} \right)^{\frac{1}{1-\sigma}}$$

- $\beta_t \rightarrow 1 \Rightarrow B_t \rightarrow 1$
- But A_t grows at a constant exponential rate!

$$\frac{\dot{A}_t}{A_t} = -\frac{1}{1-\sigma} \frac{\dot{m}_t}{m_t} = \frac{\theta}{1-\sigma}$$

- When a constant fraction of remaining goods get automated and $\sigma < 1$, the automation model features an asymptotic BGP that satisfies Uzawa

$$\alpha_{Kt} \equiv \frac{F_K K}{Y} = \beta_t^{\frac{1}{\sigma}} \left(\frac{K_t}{Y_t} \right)^{\frac{\sigma-1}{\sigma}} \rightarrow \left(\frac{\bar{s}_K}{g_Y + \delta} \right)^{\frac{\sigma-1}{\sigma}} < 1$$

Intuition for AJJ result

- Why does automation lead to balanced growth and satisfy Uzawa?
 - $\beta_t \rightarrow 1$ so the KATC piece “ends” eventually
 - Labor per task: $L/(1 - \beta_t)$ rises exponentially over time!
 - Constant population, but concentrated on an exponentially shrinking set of goods
 $\Rightarrow$ exponential growth in “effective” labor
- Labor earns 2/3 of GDP even though labor tasks are vanishing
 - **Baumol**: these are the tasks that are scarce and essential, so they demand a high share of GDP
- Limitation
 - An asymptotic result
 - Only occurs as $\beta_t \rightarrow 1$, so unclear if relevant for U.S. or other modern economies

B. Jones and Liu (AER 2024)

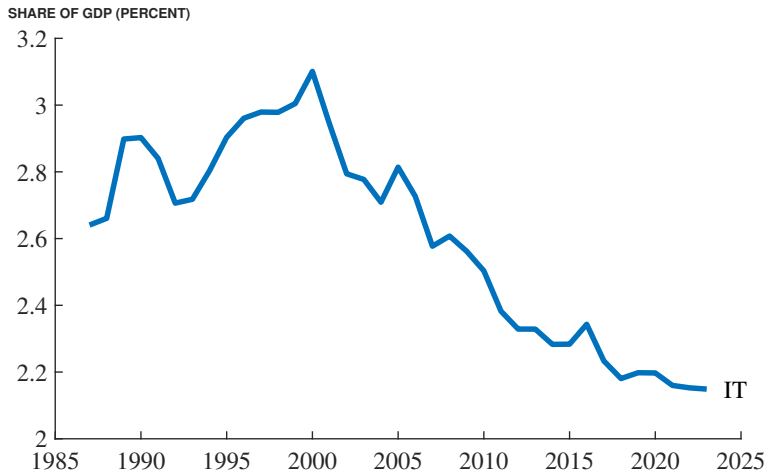
- BGP can occur “today” with $\beta_t < 1$, not asymptotically
 - Adds capital-augmenting technical change (“faster computers”) = Z_t
 - Capital share is $\alpha_{Kt} = \beta_t / Z_t$
 - Might describe modern economies
- Automation and KATC coexist along the BGP with stable factor shares
 - If β_t and Z_t rise at the same rate.
- But notice that as $\beta_t \rightarrow 1$, if $\uparrow Z_t$ continues, then the capital share falls to zero!
 - With $\sigma < 1$, the ever declining price of computers drives its factor share to zero

New project with Chris Tonetti (in progress)

- Generalize the basic model shown so far and quantify it
 - How much of historical growth in Agriculture, Motor Vehicles, and other key sectors is due to automation?
- Idea production functions?
 - How much of growth in software is due to automation?
 - Other idea PFs (harder since need to measure output of ideas)
- Speculate on what growth over the next decade due to A.I. might look like using the previous quantifications as a guide

What has happened to the factor income share of computers / IT?

What has happened to the factor income share of **computers / IT**?



Computers are everywhere, but rapid price declines dominate. $\sigma < 1$

(Jones and Tonetti, 2025)



A.I. and Ideas

A.I. in the Idea Production Function

- Let production of goods and services be $Y_t = A_t L_t$
- Let idea production be:

$$\dot{A}_t = A_t^\phi \left(\int_0^1 X_{it}^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma < 1$$

- Assume fraction β_t of tasks are automated by date t . Then:

$$\dot{A}_t = A_t^\phi F(B_t K_t, C_t S_t) \quad \text{where} \quad B_t = \left(\frac{1}{\beta_t} \right)^{\frac{1}{1-\sigma}} \quad \text{and} \quad C_t = \left(\frac{1}{1-\beta_t} \right)^{\frac{1}{1-\sigma}}$$

- This is like before...

A.I. in the Idea Production Function

- Intuition: with $\sigma < 1$ the scarce factor comes to dominate

$$F(B_t K_t, C_t S_t) = C_t S_t F\left(\frac{B_t K_t}{C_t S_t}, 1\right) \rightarrow \text{Constant} \cdot C_t S_t$$

- So, with continuous automation

$$\dot{A}_t \rightarrow A_t^\phi C_t S_t$$

- And asymptotic balanced growth path becomes

$$g_A = \frac{g_C + g_S}{1 - \phi}$$

- We get a “boost” from continued automation (g_C)

Theory: A.I. can raise growth

- Automation (computers, internet, etc.) has been ongoing for decades
 - Recall $g_C = \frac{1}{1-\sigma} \cdot \theta$
 - where θ is the fraction of remaining labor tasks that get automated each year
 $\Rightarrow$ continued automation by itself may not raise growth
- However, an **increase in the rate of automation via A.I.** $\uparrow \theta$ could raise growth
 - Rapid advances in reasoning models (OpenAI's o1-pro, o3) suggest possible!
- Extreme version: If **all** research tasks are automated, then

$$\dot{A}_t = K_t A_t^\phi$$

and a **growth explosion** is possible (e.g. if $\phi > 0$)

What would A.I. accelerating economic growth look like?

- Near-term productivity boosts from A.I.
 - **Software:** 25% productivity improvements already
 - In the next decade(!): A.I. agents that can automate most coding?
 - Virtuous circle: code up even better A.I. algorithms (infinitely usable)

What would A.I. accelerating economic growth look like?

- Near-term productivity boosts from A.I.
 - **Software:** 25% productivity improvements already
 - In the next decade(!): A.I. agents that can automate most coding?
 - Virtuous circle: code up even better A.I. algorithms (infinitely usable)
- Billions of **virtual research assistants**, running 100x faster than us
 - Automate most cognitive tasks $\Rightarrow$ invent new ideas
 - E.g. better chips, robots, medical technologies, etc.
 - A.I. + robots $\Rightarrow$ automate physical tasks
- Potential to raise growth rates substantially over the next 25 years?

Bottlenecks and Baumol Effects

- Economic history $\Rightarrow$ may take longer than we expect
 - Electricity and computers changed the economy over 50 years
- Automation has been going on for 150 years with no speed up in growth
 - Electricity, engines, semiconductors, the internet, smartphones
 - Yet growth always 2% per year
- Maybe those great ideas are what *kept* growth from slowing
 - Perhaps A.I. = latest great idea letting us maintain 2% growth for a while longer.
(pessimistic view, but possible)

The Labor Market, Jobs, and Meaningful Work

- Bottlenecks and jobs
 - Jobs are collections of tasks. Complements?
 - Even if A.I. automates a large share of tasks, humans do the remainder
 - “Weak links” $\Rightarrow$ wages can remain high — radiologists! — at least for a while
- The world where A.I. “changes everything” is a world where GDP is incredibly high
 - The size of the pie available for redistribution is enormous (transition hard?)
- As we get richer, we naturally work less
 - Rising leisure, lower retirement ages. This is a good thing!
- But there is also good, meaningful work
 - We may choose to value experiences involving people (arts, music, sports)



Catastrophic Risks?

Can we use economic analysis to think about the serious risks?

Two Versions of Existential Risk

- Bad actors:
 - Could use Claude/GPT-8 to cause harm
 - E.g. design a virus that is more lethal than Ebola and takes 3 months for symptoms
 - Nuclear weapons manageable because so rare; if every person had them...
- Alien intelligence:
 - How would we react to a spaceship near Pluto on the way to Earth?
 - “How do we have power over entities more powerful than us, forever?”
(Stuart Russell)

A Thought Experiment (Jones, 2024 AERI)

- AGI more important than electricity, but more dangerous than nuclear weapons?
- The Oppenheimer Question:
 - If nothing goes wrong, AGI accelerates growth to 10% per year
 - But a one-time small chance that A.I. kills everyone
 - Develop or not? What risk are you willing to take: 1%? 10%?

What does standard economic analysis imply?

Findings:

- Log utility: Willing to take a 33% risk!
(Maybe entrepreneurs are not very risk averse?)
- More risk averse ($\gamma = 2$ or 3), risk cutoff plummets to 2% or less
 - Diminishing returns to consumption
 - We do not need a 4th flat screen TV or a 3rd iphone.
Need more years of life to enjoy already high living standards.
- But 10% growth $\Rightarrow$ cure cancer, heart disease
 - Even $\gamma = 3$ willing to take large risks (25%) to cut mortality rates in half
 - Each person dies from cancer or dies from A.I. Just total risk that matters. . .
 - True even if the social discount rate falls to zero

How much should we spend to reduce A.I.'s catastrophic risk? (Jones 2025)

How much should we spend to reduce A.I.'s catastrophic risk? (Jones 2025)

- Covid pandemic: “spent” 4% of GDP to mitigate a mortality risk of 0.3%
 - A.I. risk is at least this large $\Rightarrow$ spend at least this much?
 - Are we massively underinvesting in mitigating this risk?

How much should we spend to reduce A.I.'s catastrophic risk? (Jones 2025)

- Covid pandemic: “spent” 4% of GDP to mitigate a mortality risk of 0.3%
 - A.I. risk is at least this large $\Rightarrow$ spend at least this much?
 - Are we massively underinvesting in mitigating this risk?
- Better intuition
 - VSL = \$10 million
 - To avoid a mortality risk of 1% $\Rightarrow$ $WTP = 1\% \times \$10 \text{ million} = \$100,000$
 - This is more than 100% of a year's per capita GDP
 - Xrisk over two decades $\Rightarrow$ **annual investment of 5% of GDP**
 - Large investments worthwhile, even with no value on future generations

How much should we spend to reduce A.I.'s catastrophic risk? (Jones 2025)

- Covid pandemic: “spent” 4% of GDP to mitigate a mortality risk of 0.3%
 - A.I. risk is at least this large $\Rightarrow$ spend at least this much?
 - Are we massively underinvesting in mitigating this risk?
- Better intuition
 - VSL = \$10 million
 - To avoid a mortality risk of 1% $\Rightarrow$ $WTP = 1\% \times \$10 \text{ million} = \$100,000$
 - This is more than 100% of a year's per capita GDP
 - Xrisk over two decades $\Rightarrow$ **annual investment of 5% of GDP**
 - Large investments worthwhile, even with no value on future generations

Incomplete: ignores the “effectiveness” of mitigation

Model

- Setup
 - One-time existential risk at probability $\delta(x)$
 - One-time investment x_t to mitigate the risk ($\delta'(x) < 0$)
 - Exogenous endowment y_t (grows rapidly via A.I.)

- Optimal mitigation:

$$\max_{x_t} u(c_t) + (1 - \delta(x_t)) \beta V_{t+1}$$

$$s.t. \quad c_t + x_t = y_t$$

$$V_{t+1} = \sum_{\tau=0}^{\infty} \beta^{\tau} u(y_{t+1+\tau}) \quad (\text{consume } y_t \text{ in future})$$

Optimal Mitigation

- FOC:

$$u'(c_t) = -\delta'(x_t)\beta V_{t+1}$$

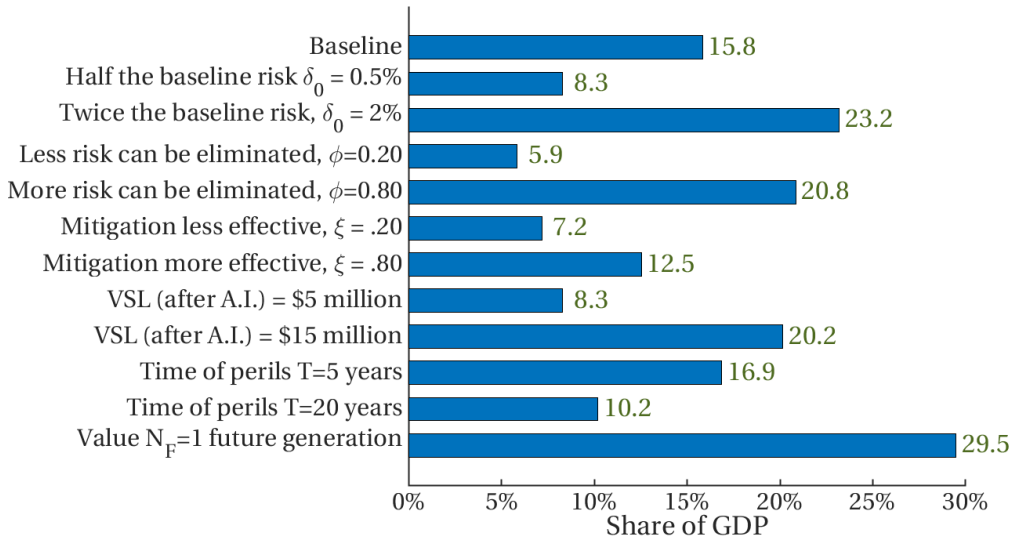
- Let $\eta_{\delta,x} \equiv -\frac{\delta'(x_t)x_t}{\delta(x_t)}$ and $s_t \equiv x_t/y_t$

$\frac{s_t}{1-s_t}$	=	$\eta_{\delta,x}$	·	$\delta(x_t)$	·	$\beta \frac{V_{t+1}}{u'(c_t)c_t}$
		effectiveness of spending > 0.01?		risk to be mitigated 1%?		value of life > 180

- Taking the smallest numbers:

$$\frac{s}{1-s} \geq 0.01 \times 1\% \times 180 = 1.8\%.$$

Optimal Spending to Reduce Existential Risk





Final Thoughts

Final Thoughts

- How much did the internet change the world between 1990 and 2020?
 - How much will A.I. change things between 2015 and 2045? More or less?
 - I believe the answer is much more
 - Just because changes take 30 years instead of 5 years does not mean that the ultimate effects will not be large
- Are we massively underinvesting in mitigating risks?
 - Easy to justify spending 1/3 of 1% of US GDP = \$100 billion!
 - Externalities and race dynamics: A.I. labs do not internalize the risks to all of us
 - Should we tax GPUs and use the revenue to subsidize safety?