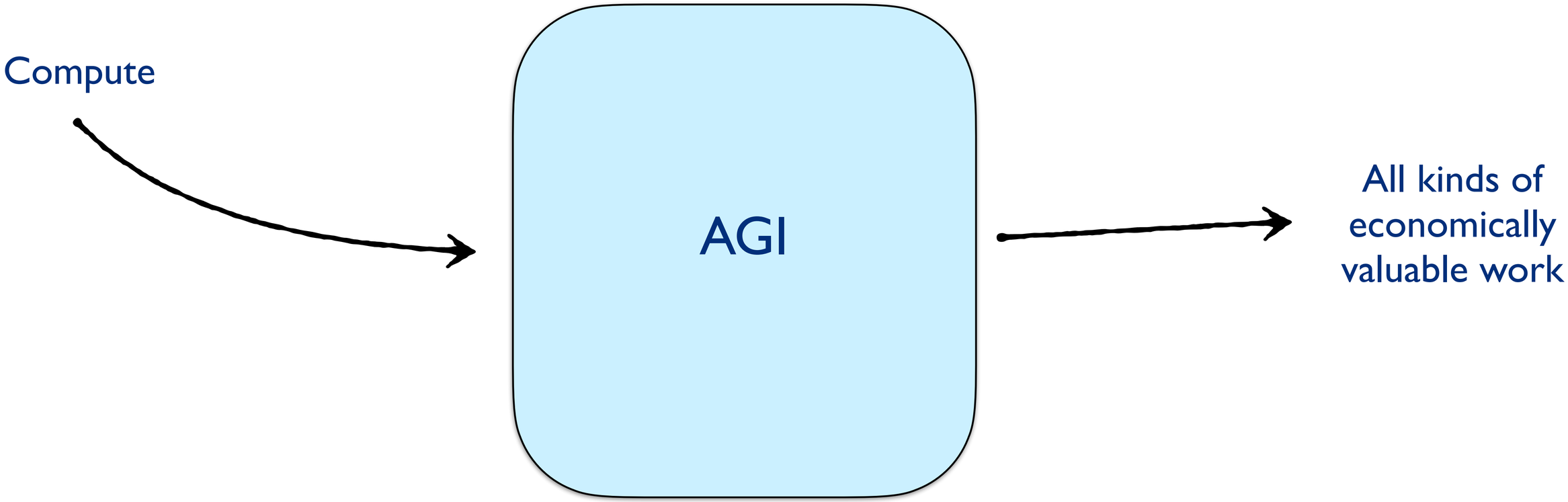
We Wont Be Missed

Work and Growth in the AGI World

Pascual Restrepo (Yale)

A Country Of Geniuses



Production In The AGI World

- Output or utility given by CRS production

$$Y_t = F(X_t), \text{ where } X_t = \{X_t(\omega)\}_{\omega \in \Omega} \text{ with } \Omega \text{ the set of all valuable work}$$

- Work ω can be produced by humans or AI systems

$$X_t(w) = L_t(\omega) + \frac{1}{\alpha_t(\omega)} Q_t(\omega)$$

- People of skill s, $H(s)$, can perform work in $\Omega(s)$ (assumed disjoint)

$$\sum_{\omega \in \Omega(s)} L_t(\omega) \leq H(s)$$

- Computational resources

$$\sum_{\omega \in \Omega} Q_t(\omega) \leq Q_t$$

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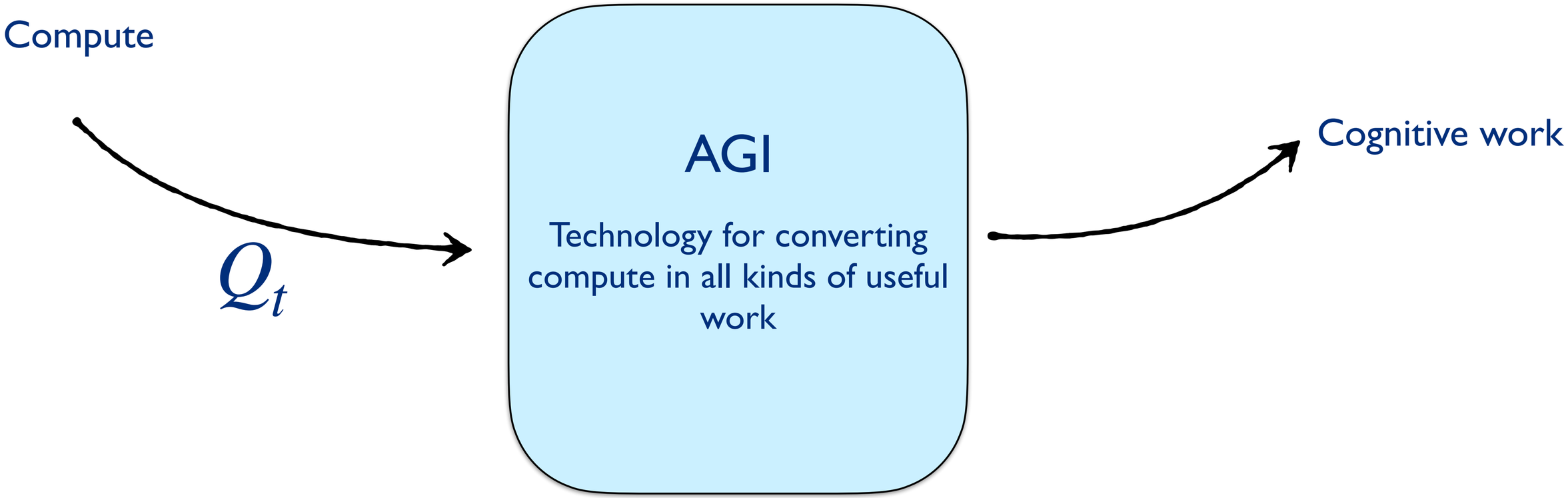
Q_t = Total computational resources per year (*Computing Progress*)

The Premise


Compute
Q_t
AGI
Technology for converting compute in all kinds of useful work
Cognitive work

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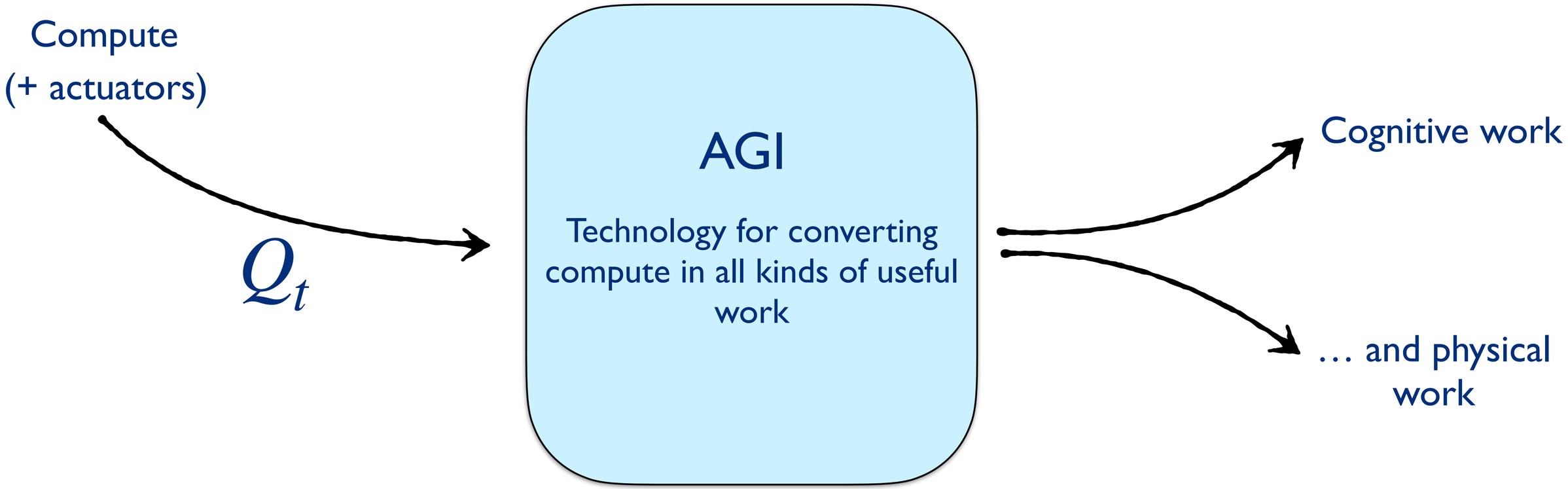
Compute
(+ actuators)
Q_t
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Technology for converting compute in all kinds of useful work
Cognitive work
… and physical work

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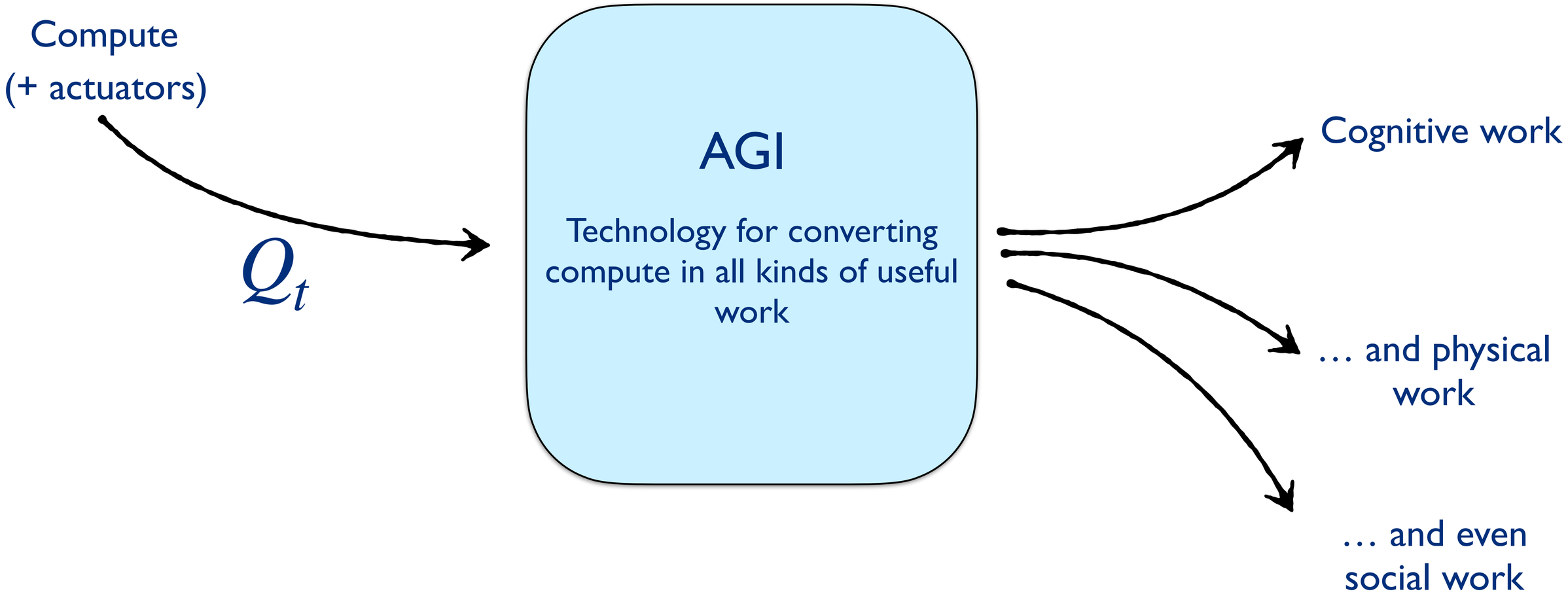
Compute
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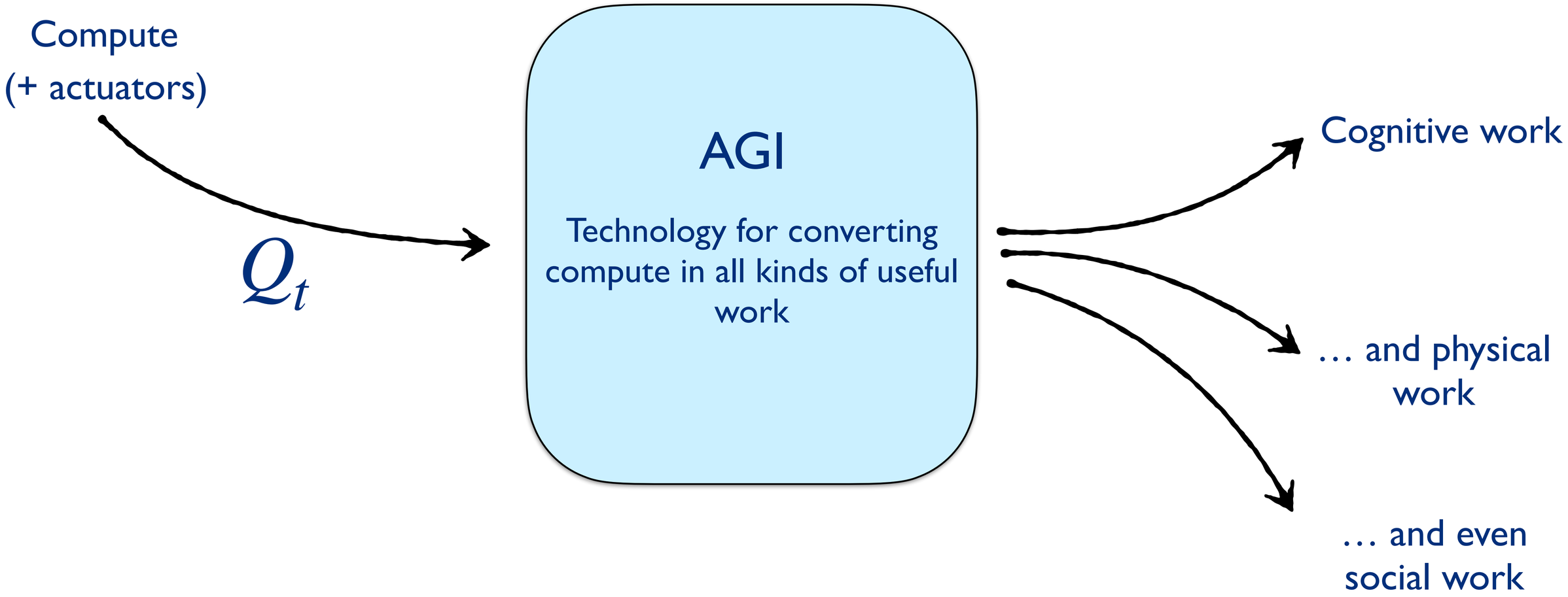
Q_t
AGI
Technology for converting compute in all kinds of useful work
Cognitive work
… and physical work
… and even social work

The Premise



This paper: limit as $Q_t \to \infty$ and $\alpha_t(\omega) \to \underline{\alpha}(\omega) < \infty$ for all Ω

Bottlenecks

Bottleneck work: Work ω is a bottleneck if, for any sequence X_t with $F(X_t)$ unbounded, either

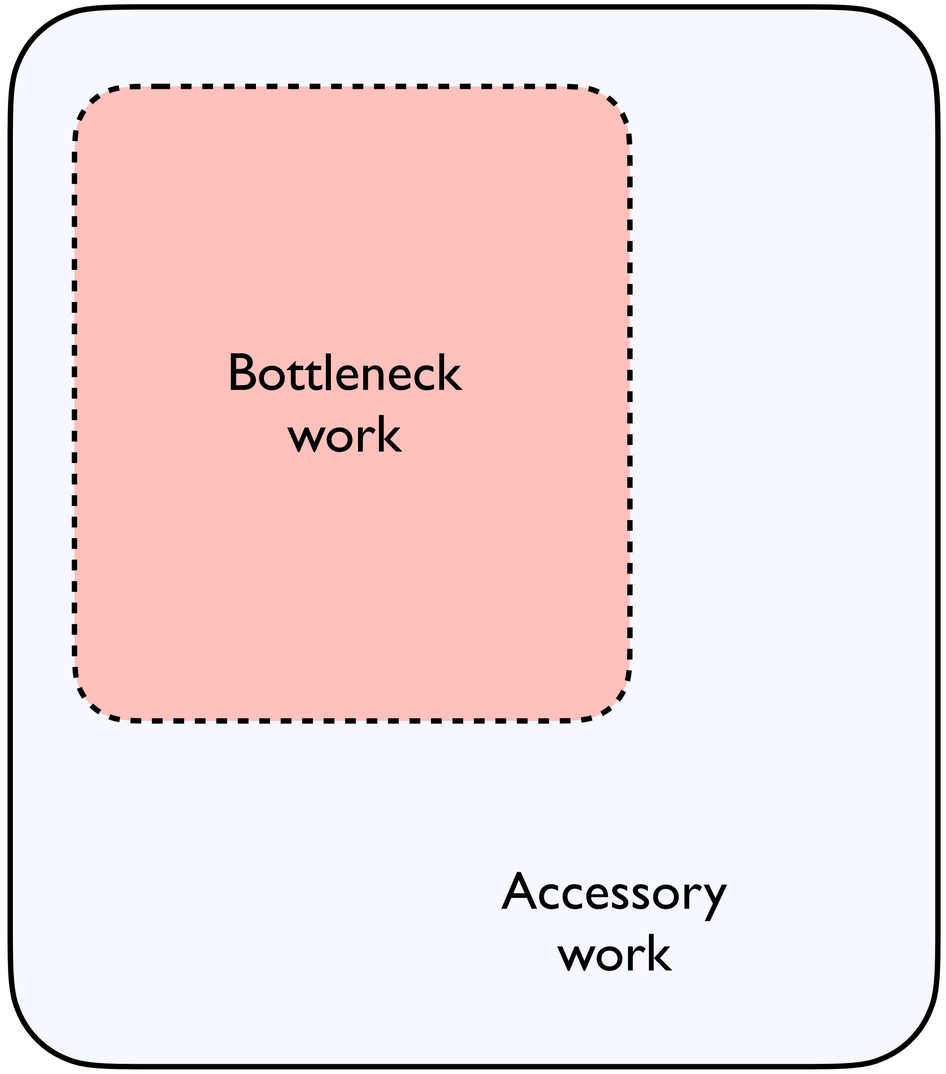
i. $X_t(\omega)$ is unbounded or

ii. $F_\omega(X_t)$ is unbounded.

Accessory work: Work ω is a accessory if there is a sequence X_t with $F(X_t)$ unbounded such that

i. $X_t(\omega)$ is bounded and

ii. $F_\omega(X_t)$ is bounded.



Ω

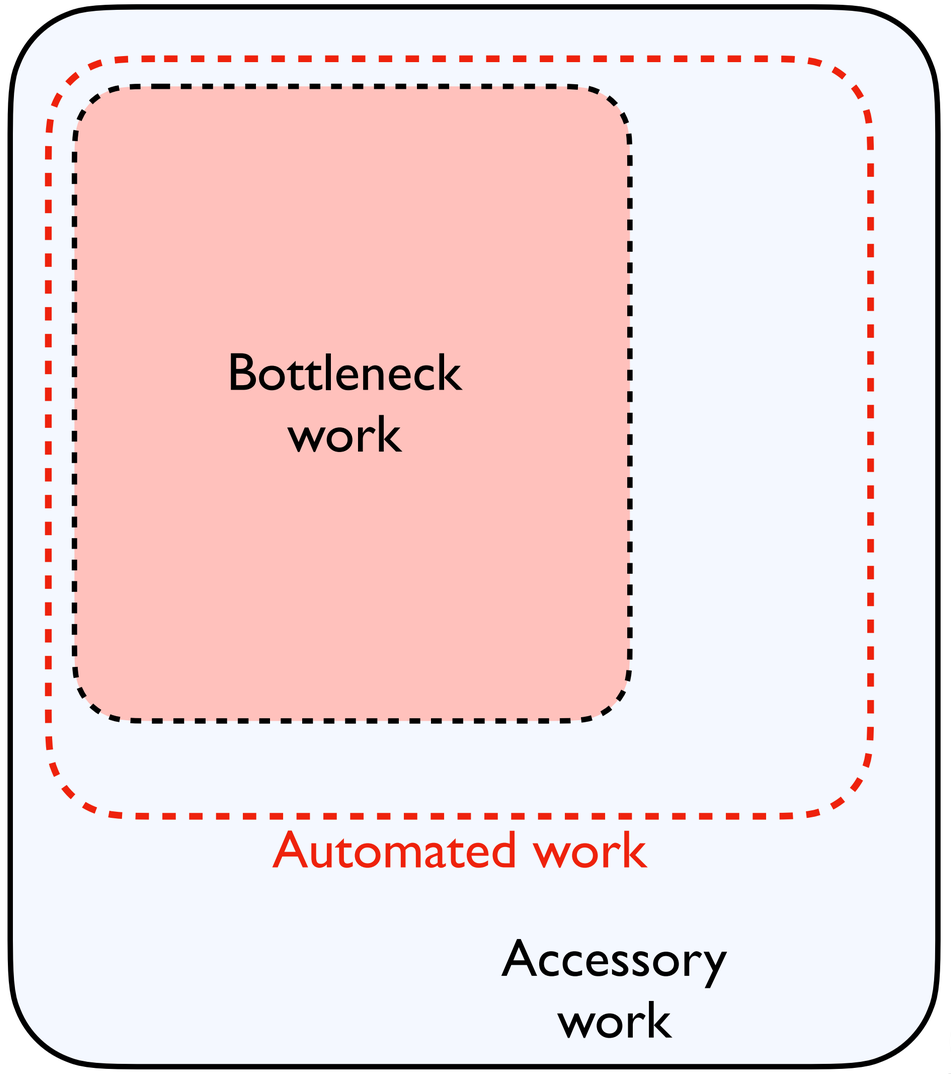
Result 1: All Bottleneck Work Is Produced By AI Systems

Argument:

Since we can produce all work with compute and compute grows, output is unbounded

Suppose AI systems <u>do not</u> produce ω:

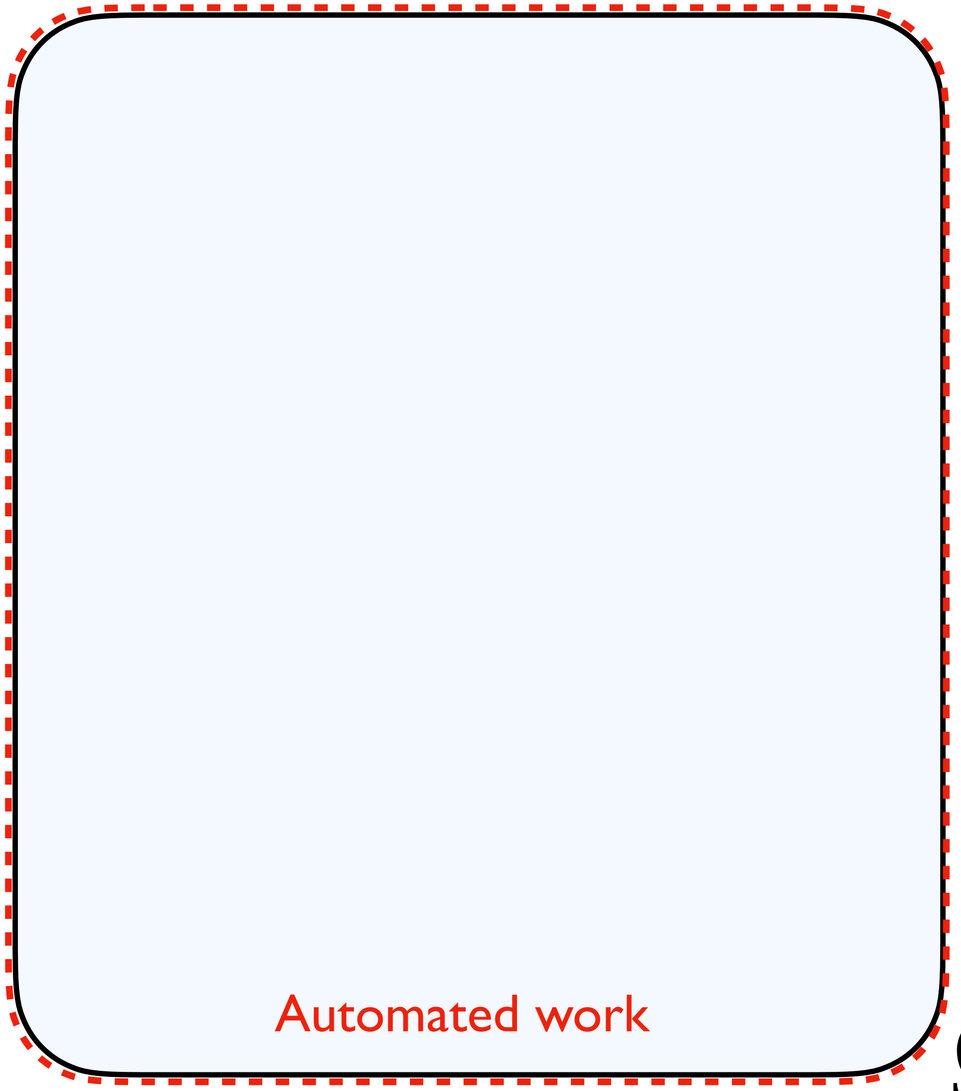
- ω is bottleneck and output is bounded ✗
- ω is bottleneck and value of ω explodes (then we would be better off using AI here) ✗
- ω is accessory ✓



The Limits Of Comparative Advantage

Imagine all work is a bottleneck. Then AI systems produce all work in the long run.

- No division of labor …
- But Ricardo taught us that we should specialize based on comparative advantage
- AI should produce bread and humans wine… ?



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Automated work would keep growing with Q_t

Non-automated work cannot keep up… This cannot be optimal

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The Limits Of Comparative Advantage

Imagine all work is a bottleneck. Then AI systems produce all work in the long run.

- Ricardo's analysis does not rule out case where advanced country (AI) produces all goods…
- What good is a world with abundance of bread and no wine?

Automated work would keep growing with Q_t

Non-automated work cannot keep up… This cannot be optimal

Ω

Result 2: Output Becomes Additive

- long run output linear in compute and skills
- Define compute-equivalent units of skill s

$$\text{CEU}(s) = \max_{\omega \in \Omega(s)} \underline{\alpha}(\omega)$$

- If all work is bottleneck, output converges to

$$Y_t = A \left(Q_t + \sum_{s \in \mathcal{S}} \text{CEU}(s)\, H(s) \right)$$

A = rate of transformation of compute into output

- Human skills still valuable and deployed at work saving the most compute $\text{CEU}(s)$

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- Human skills still valuable and deployed at work saving the most compute CEU(s)

Argument:

Economic problem (given labor allocation) is

$$\max F\left(\{ L_t(\omega) + \frac{1}{\underline{\alpha}(\omega)}\, Q_t(\omega) \} \right) \text{ st: } \sum_{\omega} Q_t(\omega) \;\leq\; Q_t$$

Since we use AI systems for all work, same as

$$\max F\left(\{ \frac{1}{\underline{\alpha}(\omega)}\, \widetilde{Q}_t(\omega) \} \right) \text{ st: } \sum_{\omega} \widetilde{Q}_t(\omega) \;\leq\; Q_t + \sum_{\omega} \underline{\alpha}(\omega)\; L_t(\omega)$$

Because of CRS, solution is linear in total resources

$$A\left(\; Q_t \;+\; \sum_{\omega} \underline{\alpha}(\omega)\; L_t(\omega) \;\right)$$

Implications

- Output scales linearly with compute

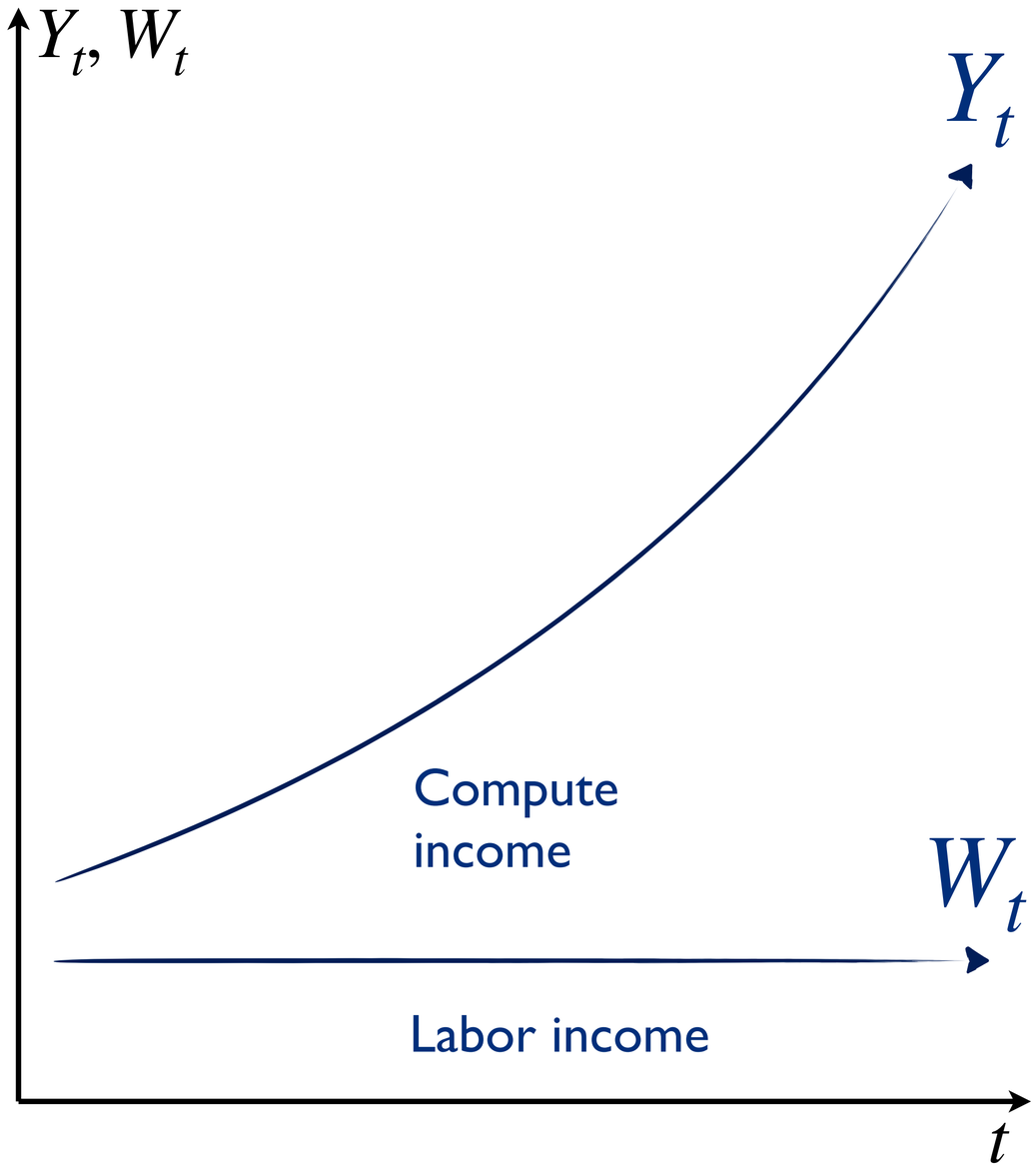
$$Y_t = A\left(Q_t + \sum_{s\in\mathcal{S}} \text{CEU}(s)\, H(s)\right)$$

- Wages well defined and positive

$$W_t(s) = A\ \text{CEU}(s)$$ — Opportunity cost of compute

- Vanishing labor share

$$\text{Labor share}_t = \frac{\sum_s \text{CEU}(s)\, H(s)}{Q_t + \sum_s \text{CEU}(s)\, H(s)} \to 0$$



Wages And Accessory Work

- Can accessory work pay growing wages?
- Two types of skills:

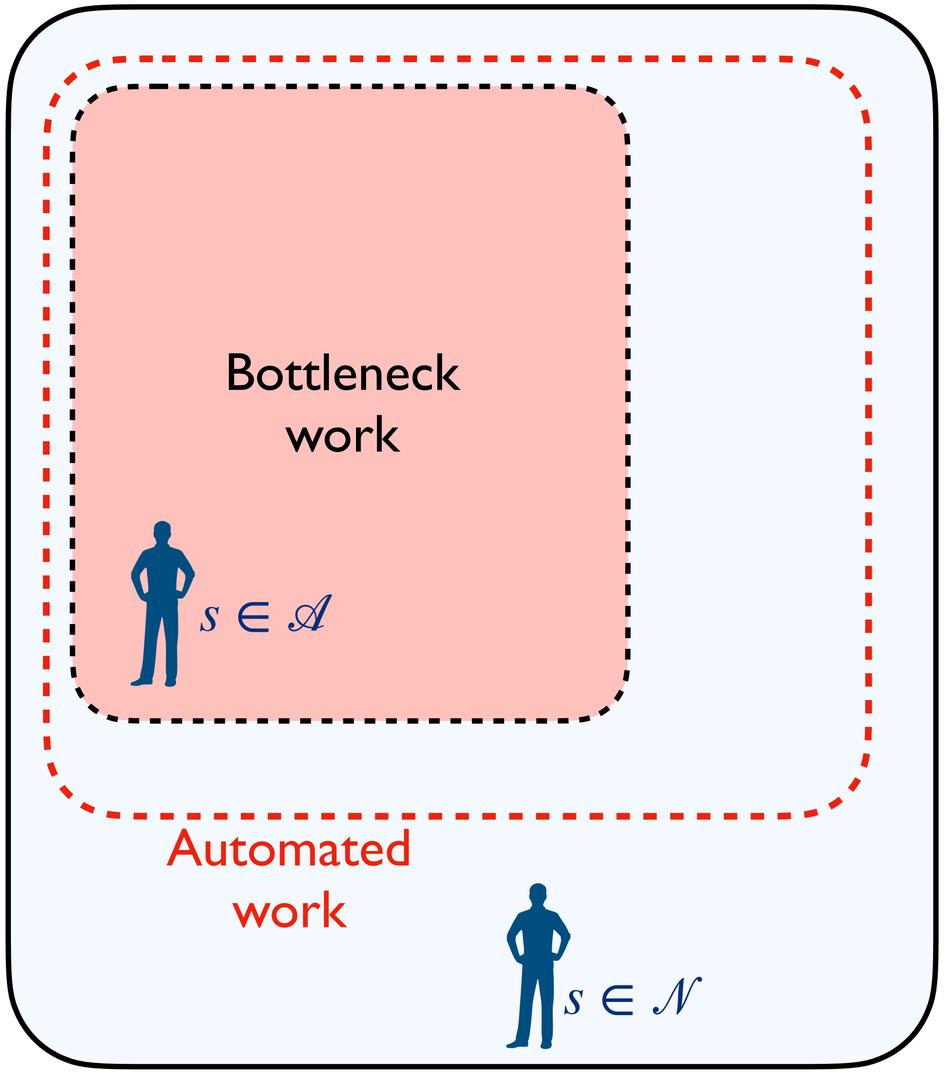
  ~ $s \in \mathscr{A}$: skills that perform only automated work

  $W_t(s) = A\ \text{CEU}(s)$ — wages pinned down by competition with AI systems

  ~ $s \in \mathscr{N}$: skills that perform some non-automated accessory work

  $W_t(s) < A\ \text{CEU}(s)$ — fact that not automated means wages below cost of producing with AI

- Stable employment but no growing wages



Result 3: Workers Are Collectively Better Off

- Mean wages at every point in the post-AGI economy exceed wages in the pre-AGI economy (with $Q_t = 0$ and $\alpha_t(\omega) = \infty$)

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Argument:

The long-run allocation maximizes output.

Suppose I take a representative group of workers and send them to a *non-AGI zone*.

The output per worker in this zone is $W_{pre-AGI}$, while the output per worker we give up is $W_{post-AGI}$.

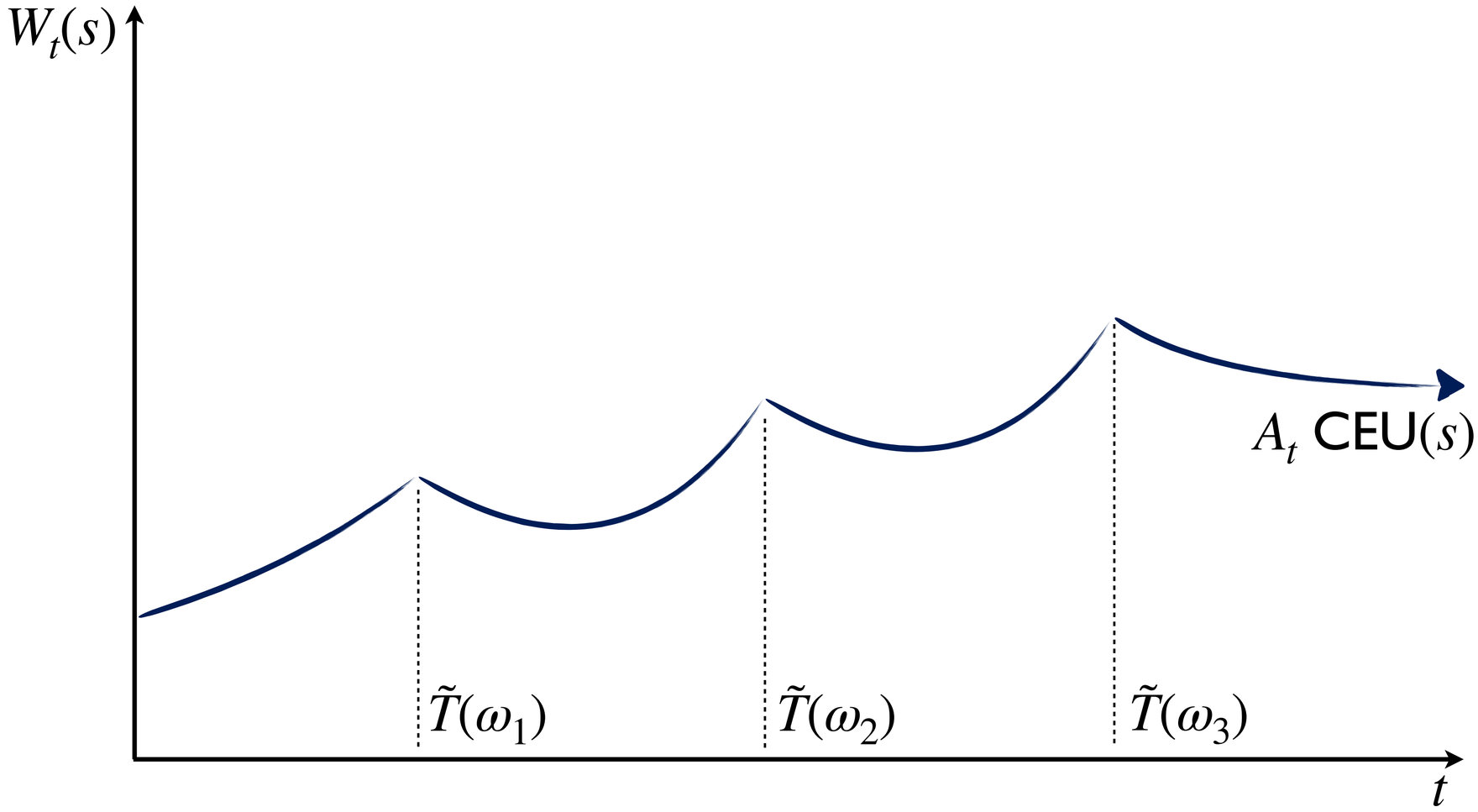
Because this cannot increase output, $W_{post-AGI} \geq W_{pre-AGI}$

Result 4: Two Types Of Transitions

- Smooth transitions when ***compute binds***

  ~ AI systems adopted when enough compute available

  ~ People displaced slowly from work once AI system starts being used and experience gradual wage decline for a while

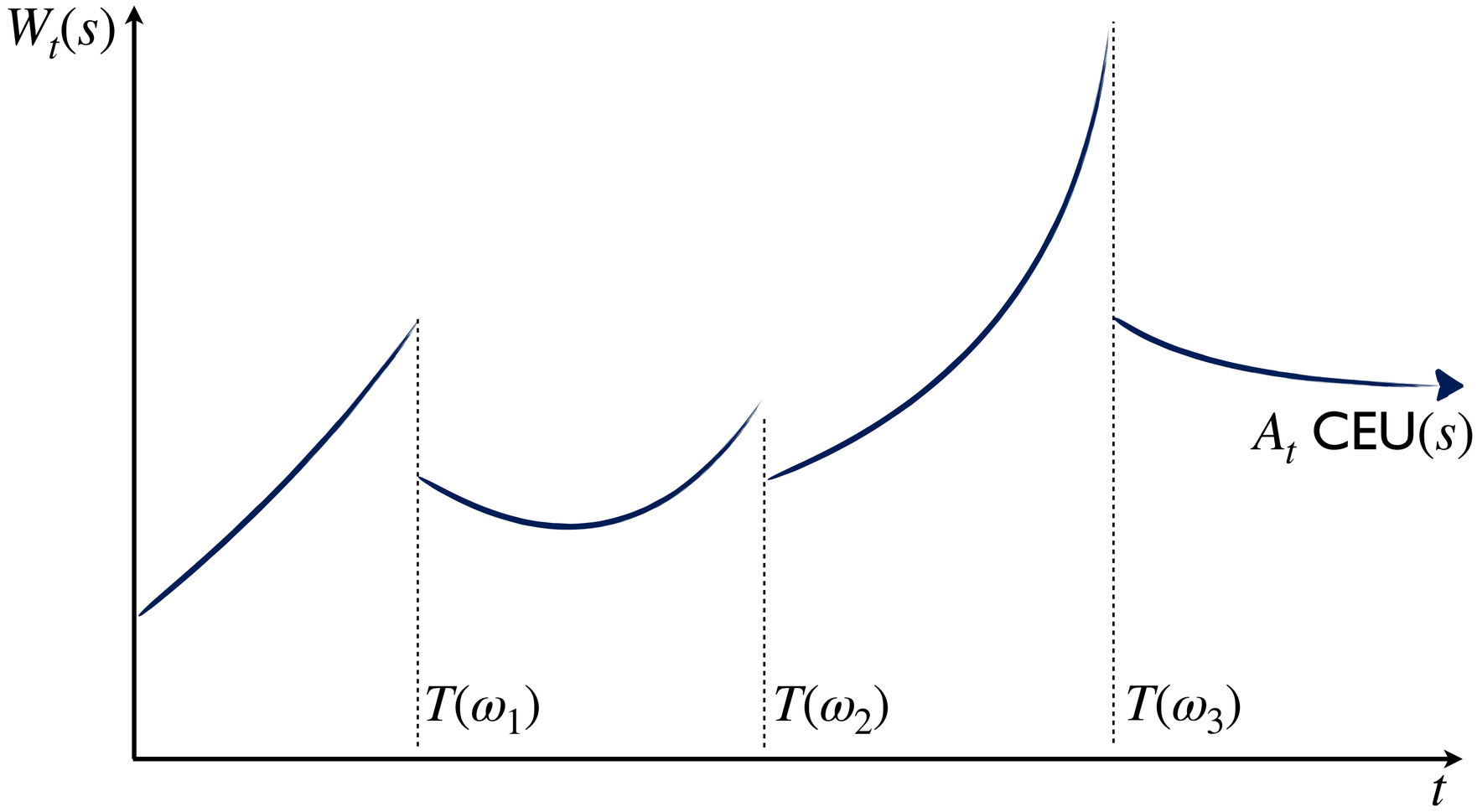


Result 4: Two Types Of Transitions

- Jagged transitions when ***technology binds***

  ~ AI systems adopted as soon as created

  ~ People displaced suddenly from automated work or experience sudden wage drop



Taking Stock

- AGI: technology for turning compute into all forms of useful work…
- All bottleneck work automated, only accessory work may be left untouched
- Labor retains value: we can replicate its output with compute, but this carries opportunity cost
- Value of labor shrinks as share of national income, even if some accessory tasks not automated
- Accessory work provides stable job opportunities but not growing wages

  ~ Most jobs today may remain unchanged if accessory

- Transition may be smooth: compute demand by *killer apps* may keep AI from being used in rest of economy

  ~ For example, use of AI for science, which I show should be prioritized in short run (see paper)

What About Work With Cultural Value?

- In arts and sports, all value derives from watching humans perform.

- Important for cultural reasons, not their instrumental value

- Can these be non-automatable bottlenecks?

  ~ Compete with AI-generated entertainment

  ~ Hard to think of something that has value for cultural reasons as bottleneck

    More about how different cultures allocate consumption and status (Tom Brady would be a *poor* Colombian)

  ~ Even if some form of art considered infinitely valuable by all of us, it would only sustain growing wages for a select few.