

# Generative AI for Economic Research: Use Cases and Implications for Economists

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# A New Paradigm for AI

## Old Paradigm, 2010s: **Deep Learning**

- had a large impact on our world
- but still a category difference between human & artificial intelligence

## New paradigm, 2020s: **Foundation models** underlying **Generative AI**

- builds on deep learning paradigm
- but qualitatively different – eerily human-like
- huge models with  $\approx 10^{12}$ + parameters and growing
  - close to complexity of human brains

## Leading category: **Large language models (LLMs)**

- like ChatGPT/Bing (GPT-4), Bard (PaLM-2, soon Gemini), Claude 2, Llama 2, ...

# Moore's Law: The number of transistors on microchips has doubled every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

## Transistor count

50,000,000,000

10,000,000,000

5,000,000,000

1,000,000,000

500,000,000

100,000,000

50,000,000

10,000,000

5,000,000

1,000,000

500,000

100,000

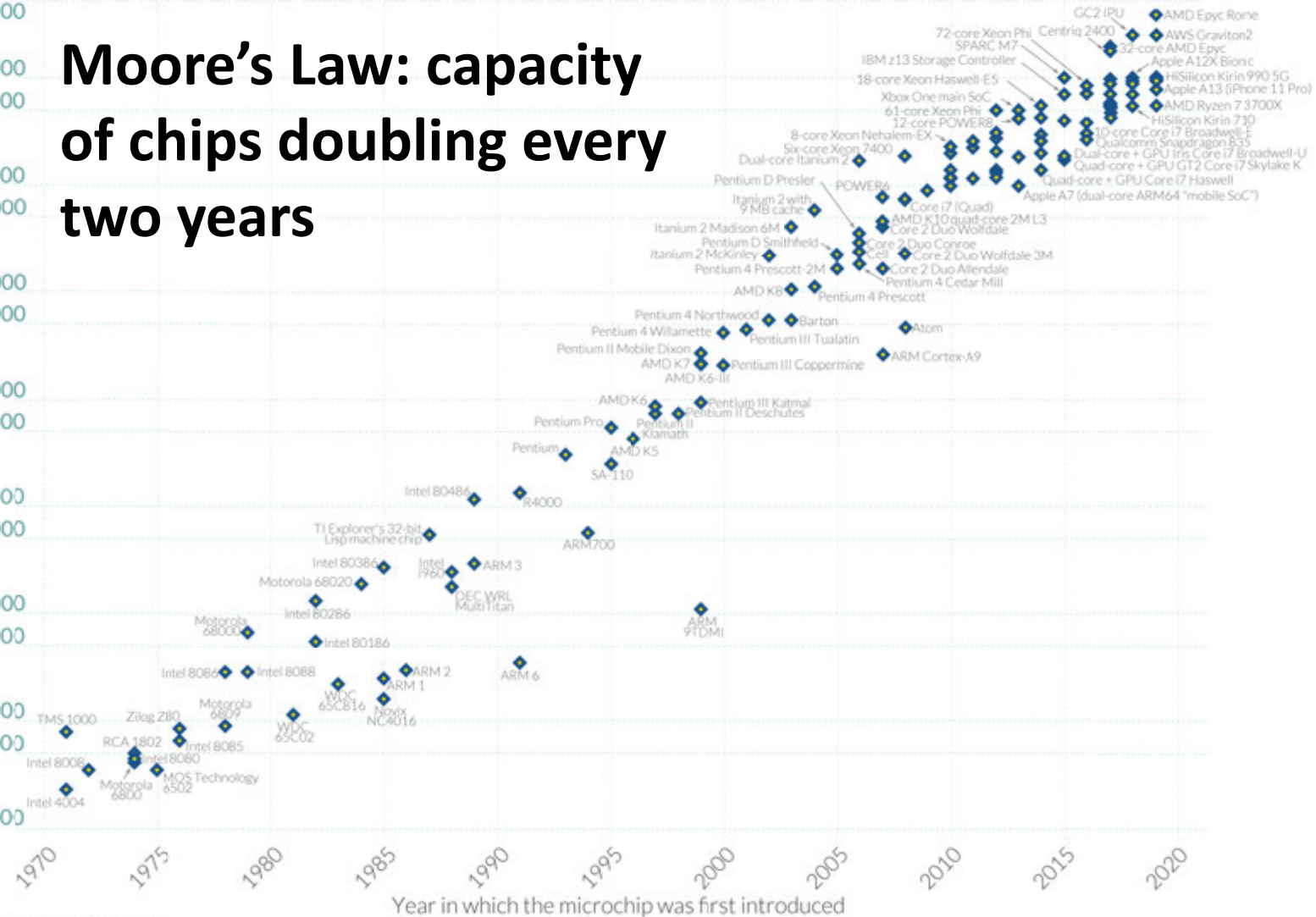
50,000

10,000

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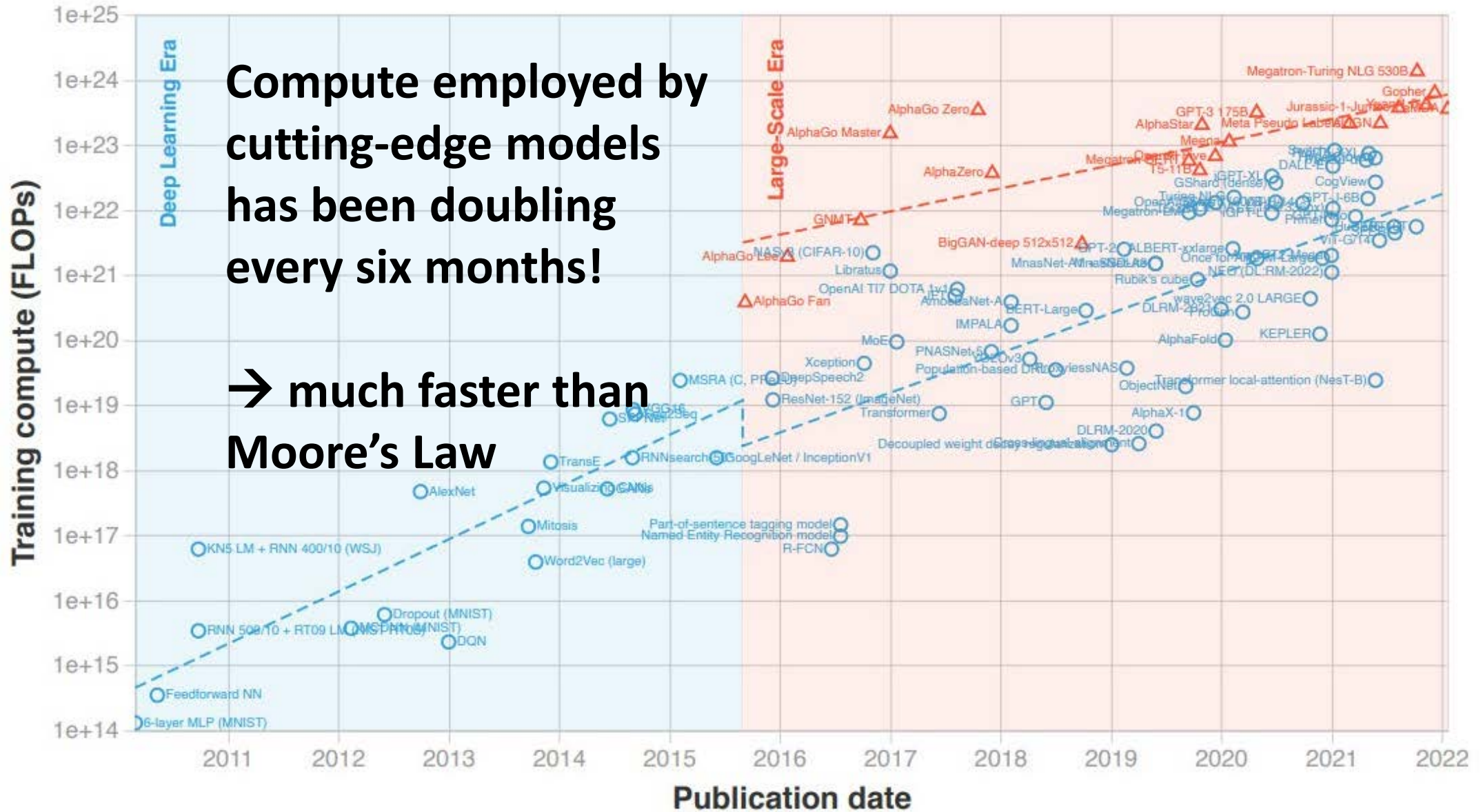
## Moore's Law: capacity of chips doubling every two years



Data source: Wikipedia ([wikipedia.org/wiki/Transistor\\_count](https://wikipedia.org/wiki/Transistor_count))

# Training compute (FLOPs) of milestone Machine Learning systems over time

n = 102



Compute employed by cutting-edge models has been doubling every six months!

→ much faster than Moore's Law

# Two Camps on the Significance of LLMs

## 1. Camp “Stochastic parrots” or “Advanced auto-complete”

- emphasizes limitations

## 2. Camp “Human-level AI”

- emphasizes capabilities

→ easy to over- or underestimate current LLMs – and dangerous to do so!

→ their capabilities and “intelligence” are very different from ours

My claim in this paper: LLMs are useful in conducting research

# Training, Capabilities, and World Models

**Training of modern LLMs proceeds in 3 steps:**

**Step 1: Pre-training** (very costly: > \$100m for GPT-4, Gemini):

- LLM base model is pre-trained via “self-supervised” learning:
  - system is fed vast amounts of data
  - banal training objective: to predict the next word (token) in a sentence
- During this process, the model learns to represent the distribution of words in its training corpus
  - but to do so efficiently, the model develops an internal **representation or model of the world**

# Training, Capabilities, and World Models

**Training of modern LLMs proceeds in 3 steps:**

**Step 2: Instruction fine-tuning** via supervised learning:

- LLM is taught to follow instructions rather than just continuing text:
  - fine-tuning to answer questions, summarize texts, brainstorm, etc.
  - but all this draws on the pre-trained foundation

**Step 3: Reinforcement learning from human feedback (RLHF):**

- Model learns how much humans like answer → teaches LLM to be more truthful, sound authoritative, refrain from hateful text, etc.

# Scaling and Emergent Capabilities

- **Scaling:** predictable performance gains from increase in training compute → “scaling laws” on how more parameters & training data reduce log-loss
- **Emergent capabilities:** arise unexpectedly at discrete points:
  - LLMs could suddenly translate, rhyme, do math, etc.
- **Multi-modal models:** LLMs combined with other modalities leading to rapid progress in other domains  
e.g., robots with world models leading to rapid advances in robotics



# Advice on Prompts

Lots of attention has been paid to “**prompt engineering**”

**My own advice: treat** the LLM (esp GPT-4) **as if it was an intern** who is:

- smart and incredibly motivated & eager to help
- but completely lacks the context of what you are doing

→ provide context

→ iterate

→ be patient

# Limitations

- **Analytic concepts:** language models are good for language – they are less solid on analytic concepts – but plugins offer analytic power
  - **Data cut-off:** training data usually cuts off in the past (e.g. Fall 2021 for GPT-3.5/4) - but Feb 2023 for PaLM-2
  - **Context window:** length of text limited – but 100k tokens for Claude 2
  - **Sessions:** models only learn from their training data and do not remember across sessions
  - **Randomness:** limits reproducibility: even with temperature = 0!
- many of these limitations are regularly being pushed out...

# Risks

- **Information security:** important for sensitive data
- **Hallucination:** LLMs are prone to make up things, esp when pushed to their limits: e.g., incorrect facts, citations, etc.  
→ this is getting better
- **Bias:** output builds on the corpus of training data
- **Homogeneity:** we all use the same models

# Useful Capabilities for Economists

**Six categories of capabilities**, with several dozen sample use cases:

1. Ideation and feedback
2. Writing
3. Background research
4. Coding
5. Data analysis
6. Math

available at [www.korinek.com](http://www.korinek.com)

Category	Task	Usefulness
Ideation and Feedback	Brainstorming	●
	Feedback	◐
	Providing counterarguments	◐
Writing	Synthesizing text	●
	Editing text	●
	Evaluating text	●
	Generating catchy titles & headlines	●
	Generating tweets to promote a paper	●
Background Research	Summarizing Text	●
	Literature Research	○
	Formatting References	●
	Translating Text	●
	Explaining Concepts	◐

The third column reports my subjective rating of LLM capabilities as of September 2023:

○: experimental; results are inconsistent and require significant human oversight

◐: useful; requires oversight but will likely save you time

●: highly useful; incorporating this into your workflow will save you time

Category	Task	Usefulness
Coding	Writing code	◐
	Explaining code	◐
	Translating code	●
	Debugging code	◐
Data Analysis	Creating figures	◐
	Extracting data from text	●
	Reformatting data	●
	Classifying and scoring text	◐
	Extracting sentiment	◐
	Simulating human subjects	◐
Math	Setting up models	◐
	Deriving equations	○
	Explaining models	◐

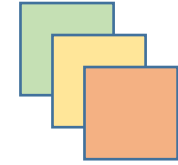
The third column reports my subjective rating of LLM capabilities as of September 2023:

○: experimental; results are inconsistent and require significant human oversight

◐: useful; requires oversight but will likely save you time

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# Evaluating & Scoring Capabilities



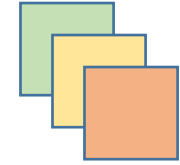
I will subjectively categorize the capabilities of existing systems as follows:

<b>3 – green</b>	capability is very well-developed & quite robust, highly useful – recommended
<b>2 – yellow</b>	capability works in limited circumstances, occasionally useful – good to experiment
<b>1 – red</b>	capability is emerging, useful with serious limitations – experiment at your own risk

Important reminder:

- capabilities are emerging rapidly, and this may make it useful to familiarize yourself even with experimental ones

# Useful Capabilities for Economists



## **Ideation and Feedback** (generating, selecting, developing of ideas):

- Brainstorming ideas
- Offering feedback
- Providing counterarguments
- Evaluating ideas



**Chat 1 (GPT-4):** Can you brainstorm 20 channels through which AI may increase inequality? Limit your response to 10 words for each point.

1. Job loss due to automation in lower-skilled industries.
2. AI-driven wealth concentration in tech-savvy organizations.
3. Digital literacy gap leading to economic disparity.
4. Lack of universal access to AI technology.
5. AI-driven bias in hiring and selection processes.
6. Imbalance in job market due to AI specializations.
7. Data privacy issues affecting vulnerable populations.
8. AI-driven services predominantly targeting wealthy consumers.
9. Algorithms exacerbating social inequality through bias.
10. Inclusive AI product development lacking.
11. Higher prices due to AI-enhanced products/services.
12. AI-fueled gentrification in tech-centered cities.
13. Anticompetitive practices bolstered by AI applications.
14. Lack of labor rights for jobs displaced by AI.
15. Educational imbalance due to AI-learning tools.
16. AI in healthcare excluding lower socioeconomic groups.
17. Disproportionate influence of AI in political campaigns.

## Chat 2 (GPT-4): What are the top-3 pros and cons of working on the economics of AGI?

### Pros of Working on the Economics of AGI:

1. **High Impact:** The development of AGI (Artificial General Intelligence) has the potential to revolutionize many sectors of the economy, from healthcare to finance to transportation. Working on the economics of AGI allows you to be at the forefront of this transformation and potentially shape its direction.
2. **Interdisciplinary Approach:** The economics of AGI involves a combination of economics, computer science, and philosophy, among other disciplines. This interdisciplinary approach can be intellectually stimulating and rewarding.
3. **Potential for Innovation:** Given that AGI is a relatively new and rapidly evolving field, there is a lot of room for innovative thinking and novel approaches. This can be exciting and fulfilling for those who enjoy problem-solving and creative thinking.

### Cons of Working on the Economics of AGI:

1. **Uncertainty:** The future of AGI is highly uncertain, making it difficult to make accurate predictions or develop robust economic models. This uncertainty can make the work challenging and sometimes frustrating.
2. **Ethical and Societal Implications:** The development and deployment of AGI

**Chat 3 (Claude 2):** Can you suggest ways to improve this paper?  
**[Attachment: w30957.pdf]**

Here are some suggestions for improving the paper on large language models and cognitive automation:

- Provide more specific details and examples when describing the different use cases. For some of them, the explanations are a bit vague. Adding more concrete illustrations would strengthen those sections.
- Expand the discussion of the limitations and potential downsides of over-relying on LLMs. The paper focuses mostly on the benefits, but more balance discussing the risks would be helpful.
- Strengthen the analysis of the long-term implications. The outlook section is thought-provoking but remains speculative. Adding more rigorous analysis to back up the predictions could make it more convincing.
- Consider testing the use cases on multiple LLMs and comparing their capabilities. The examples all seem to use a single LLM, but testing different ones could reveal variation in strengths/weaknesses.

# A Few Other Brainstorming Strategies

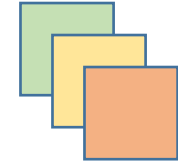
- I am an economist working on AI and inequality. Can you brainstorm
  - Can you brainstorm an outline on [insert topic]?
  - 20 potential paper topics and describe each in one sentence?
- I am an economist working on an academic paper on [insert topic]. Can you brainstorm a research plan for me?

Iteration between brainstorming and evaluating ideas works especially well.

**Chat 4 (GPT-4):** I am working on an economic model that predicts that cognitive automation will increase inequality. What are the top 5 counterarguments? One line each.

1. Cognitive automation could lead to job creation in new sectors, offsetting job losses in others.
2. It may increase productivity and economic growth, leading to overall wealth increase.
3. Automation could potentially lower the cost of goods and services, benefiting all consumers.
4. It could provide opportunities for upskilling and reskilling, leading to wage growth.
5. Cognitive automation might reduce human error, increasing efficiency and potentially leading to more equitable outcomes.

# Useful Capabilities for Economists



## Writing:

- Synthesizing text
- Providing examples
- Evaluating text
- Editing text (for mistakes, style, clarity, simplicity, ...)
- Generating catchy titles & headlines
- Generating tweets / promotional materials



**Chat 5 (GPT-4):** Write a paragraph in the style of an academic economist that integrates the following points. Include a topic sentence.

- \* large language models (LLMs) automate many cognitive tasks
- \* the work of academic economists is largely cognitive [add examples]
- \* we economists should therefore worry about recent progress in language models
- \* in the short run, these models can help us be more productive
- \* in the long run, there is a good likelihood that they will displace human economists
- \* we should think how to prepare [offer solutions]

The advent of large language models (LLMs) that automate a plethora of cognitive tasks presents a significant paradigm shift that academic economists should be cognizant of, given the cognitive nature of our work, which includes tasks such as data analysis, economic forecasting, and policy recommendation. The rapid advancements in language models could potentially disrupt our profession, necessitating a proactive approach to this emerging technology. In the short term, these models can augment our productivity by automating routine tasks, thereby allowing us to focus on more complex and nuanced aspects of economic research. However, in the long run, there is a substantial likelihood that these models could displace human economists, as they become increasingly adept at performing com-

**Chat 6 (GPT-4):** Can you correct the following sentence?

These paper describe six domain in which large language models (LLMs) displays emergant capbilities that are useful to the economic research.

**This paper describes six domains** in which large language models (LLMs) **display emergent capabilities** that are useful **for** economic research.

**Chat 6 (GPT-4) ctd.:** Can you explain the main corrections you made?

Sure, here are the main corrections:

1. "These paper" was corrected to "This paper". The subject-verb agreement was incorrect. If the subject is singular (like "paper"), the verb should also be singular (like "describes").
2. "describe" was corrected to "describes". The verb should match the singular subject "paper".
3. "domain" was corrected to "domains". The context implies that there are multiple domains, so the plural form should be used.
4. "displays" was corrected to "display". The subject "LLMs" is plural, so the verb should also be plural.
5. "emergant" was corrected to "emergent". This was a spelling mistake.



**Chat 7 (GPT-4):** Give a concise list of the top 5 stylistic shortcomings of the following abstract:

Generative AI, in particular large language models (LLMs) such as ChatGPT, has the potential to revolutionize research. I describe dozens of use cases along six domains in which LLMs are starting to become useful as both research assistants and tutors: ideation and feedback, writing, background research, data analysis, coding, and mathematical derivations. I provide general instructions and demon-

1. **Lack of Clarity:** The abstract uses jargon and technical terms without providing clear definitions or explanations, making it difficult for readers unfamiliar with the topic to understand.
2. **Overuse of Passive Voice:** The abstract frequently uses passive voice, which can make the writing seem less direct and engaging.
3. **Lack of Specificity:** The abstract mentions "dozens of use cases" and "six domains" but does not provide any specific examples or details.
4. **Redundancy:** The abstract repeats the idea of AI's potential benefits for economists multiple times without adding new information.
5. **Lack of Structure:** The abstract does not have a clear structure or flow, making it difficult for readers to follow the author's argument.

## Chat 7 (GPT-4) ctd.: Can you rewrite it to correct these shortcomings?

Generative AI, specifically large language models (LLMs) like ChatGPT, holds the potential to transform research. This paper explores the application of LLMs in six key areas: ideation and feedback, writing, background research, data analysis, coding, and mathematical derivations. For each area, I provide practical instructions and real-world examples, categorizing the usefulness of LLMs from experimental to highly beneficial.

The focus of this paper is on the potential benefits for economists. By leveraging generative AI, economists can automate micro tasks, leading to significant productivity gains. As AI systems continue to evolve, these benefits are expected to increase.

The paper also delves into the long-term implications of AI-powered cognitive automation for economic research. Accompanying online resources provide a step-by-step guide on how to get started with generative AI, along with regular updates on its latest capabilities beneficial for economists.

# Further Prompt Examples on Style

- Rewrite the following text
  - in a style that is comprehensible to non-economists
  - in a style that is accessible to policymakers with a PhD degree
  - in the style of [enter your favorite economist, politician, comedian]
- Which arguments are the hardest to follow in the following text?
- Evaluate the clarity and coherence of the following text.
- Are there any ambiguities in the following text?

**Chat 8 (GPT-4):** Brainstorm two or three catchy titles for a paper with the following abstract:

**[Abstract from Chat 7]**

1. "Revolutionizing Economic Research: The Power of Generative AI and Large Language Models"
2. "Unleashing AI in Economics: A Comprehensive Guide to Utilizing Large Language Models"
3. "The Future of Economic Research: Harnessing the Potential of Generative AI and Large Language Models"

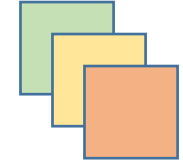
**Chat 8 (GPT-4) ctd.:** Make them a bit more sober and keep them short.

1. "Generative AI in Economic Research"
2. "Large Language Models: A New Tool for Economists"
3. "The Role of AI in Modern Economic Studies"

**Chat 9 (GPT-4):** Write three or four tweets that summarize the following text. Use simple sentences and make them catchy:  
**[Abstract from Chat 7]**

1. "Generative AI, especially large language models like ChatGPT, are set to revolutionize research! They're becoming handy as research assistants and tutors across six domains. #AIRevolution #ChatGPT"
2. "From ideation to coding, generative AI is proving useful in a variety of tasks. Economists, it's time to automate your micro tasks and boost productivity! #AIProductivity #Economics"
3. "The future of AI-powered cognitive automation in economic research looks promising. Stay tuned for regular updates on the latest capabilities of generative AI. #FutureOfAI #EconomicResearch"
4. "Want to get started with generative AI? Check out the online resources associated with my paper for instructions and updates. #GenerativeAI #AIResources"

# Useful Capabilities for Economists



## Background Research:

- Researching the literature
- Summarizing text
- Formatting references
- Translating text
- Explaining concepts

**Chat 10 (GPT-4):** Summarize the following text in one sentence:

**[Abstract from Chat 7]**

The author discusses the potential of Generative AI, specifically large language models like ChatGPT, to revolutionize research in various domains such as ideation, writing, data analysis, coding, and mathematics, and suggests that economists can significantly increase productivity by automating micro tasks with AI, with the performance of these systems expected to improve over time.



**Chat 11 (Claude 2):** Provide a short summary of this paper.  
**[Attachment: w30957.pdf]**

This paper describes how large language models (LLMs) like ChatGPT are starting to display useful capabilities across a range of research tasks in economics. The author categorizes 25 potential use cases into six domains: ideation, writing, background research, data analysis, coding, and mathematical derivations. For each domain, the paper provides instructions and examples to demonstrate current LLM abilities, rating them on a scale from experimental to highly useful. The author argues LLMs can help automate micro tasks and increase researcher productivity in the short run. In the long run, the paper speculates cognitive automation via LLMs may have profound implications for economic research and the value of human cognitive labor.



**Chat 12 (GPT-4):** Provide citation information for Anton Korinek's paper with Zach Bethune.

Bethune, Z., & Korinek, A. (2021). Covid-19 Infection Externalities: Trading Off Lives vs. Livelihoods. *Journal of Monetary Economics*, 117, 1-13.

**Chat 13 (GPT-4):** Convert the following reference to bibtex format:

Anton Korinek, Large Language Models and Cognitive Automation for Economic Research, NBER Working Paper 30957, February 2023.

```
@techreport{korinek2023large,  
title={Large Language Models and Cognitive Automation for Economic Re-  
search},  
author={Korinek, Anton},  
year={2023},  
institution={NBER},  
type={Working Paper},  
number={30957},  
month={February}  
}
```

**Chat 13 (GPT-4) ctd.:** Format it in Chicago style.

Korinek, Anton. 2023. "Large Language Models and Cognitive Automation for Economic Research." NBER Working Paper No. 30957, February.

**Chat 14 (GPT-4):** Translate the following sentence into Spanish, German, and Finnish:

Generative AI, in particular large language models (LLMs) such as ChatGPT, has the potential to revolutionize research in many disciplines.

Spanish: La IA generativa, en particular los modelos de lenguaje grandes (LLMs) como ChatGPT, tiene el potencial de revolucionar la investigación en muchas disciplinas.

German: Generative KI, insbesondere grosse Sprachmodelle (LLMs) wie ChatGPT, hat das Potenzial, die Forschung in vielen Disziplinen zu revolutionieren.

Finnish: Generatiivinen teko aaly, erityisesti suuret kielen mallit (LLM) kuten ChatGPT, on potentiaalia mullistaa tutkimusta monilla aloilla.

## **Chat 15 (GPT-4):** What are instrumental variables useful for?

Instrumental variables are useful for addressing issues of endogeneity in statistical analysis, particularly in regression analysis. Endogeneity can occur due to unobserved variables, measurement errors, or simultaneity, which can lead to biased and inconsistent parameter estimates.

Instrumental variables are used to isolate the effect of the variable of interest from the effects of other confounding variables. They are particularly useful in situations where it is not possible to directly observe all relevant variables, or where the variable of interest is correlated with the error term.

In addition, instrumental variables can be used to estimate causal relationships in observational data, where random assignment of treatments is not possible. They provide a way to mimic the conditions of a randomized controlled trial, which is considered the gold standard for causal inference.

# Tutoring/Explaining concepts

Try a few additional examples:

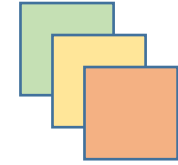
1. What is the invisible hand theorem and why does it hold?
2. Why are instrumental variables useful?
3. What is Monte Carlo simulation?
4. What are the leading theories of exchange rate determination?
5. What is the second theorem of welfare economics?

**Chat 16 (GPT-3.5):** What is the second theorem of welfare economics?





The Second Theorem of Welfare Economics states that any competitive equilibrium is Pareto efficient. This means that any competitive market outcome is the most efficient outcome possible, as it cannot be improved upon without making at least one individual worse off.

**(Author's note: this is clearly the first not the second theorem!)**

# Useful Capabilities for Economists



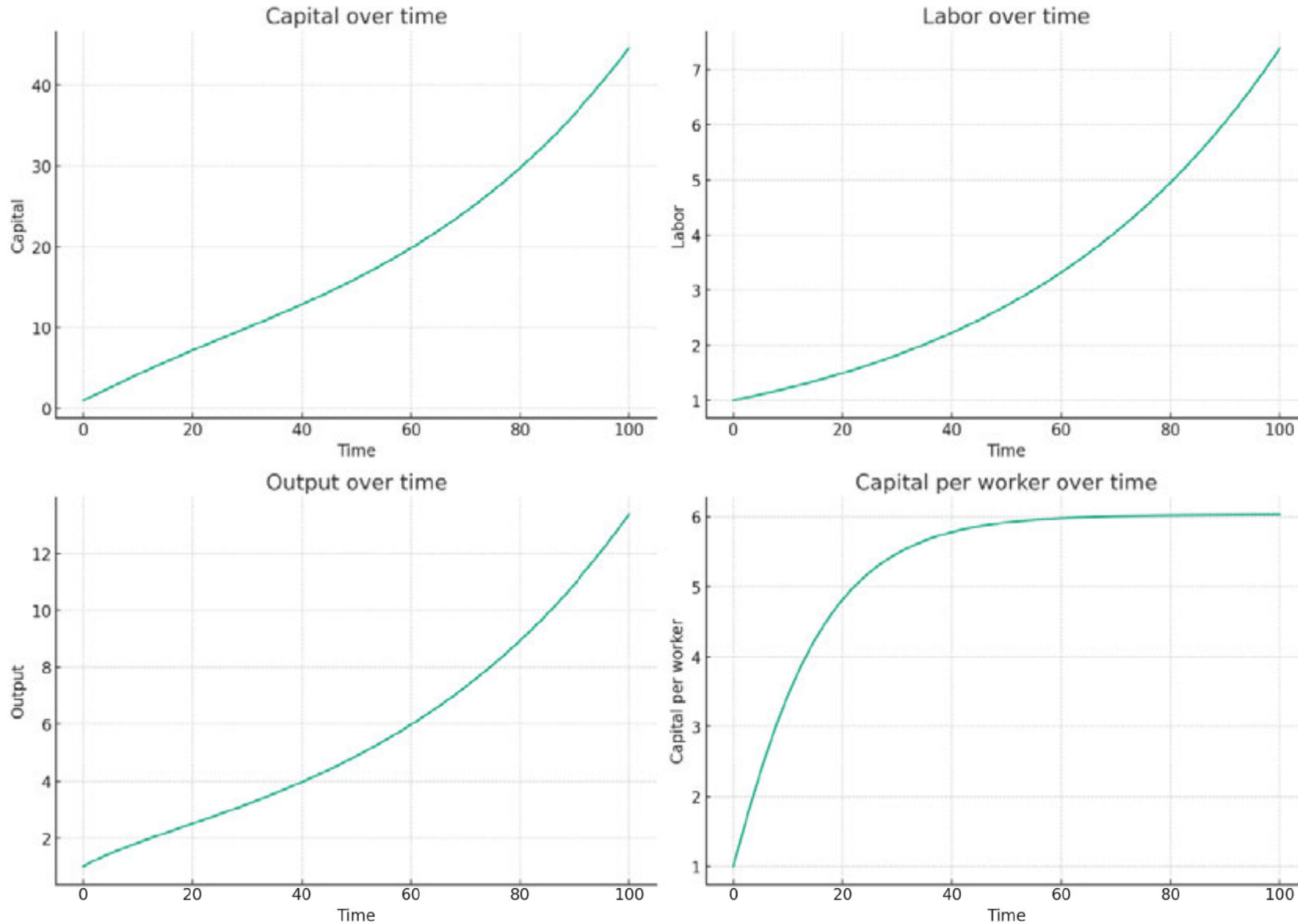
## Coding:

-  • Writing code
-  • Explaining code
-  • Translating code
-  • Debugging code

→ also accessible in GitHub as Copilot

→ works best in python & R but capable of many other languages

# Chat 17 (ChatGPT Advanced Data Analysis): Simulate the Solow growth model and plot the results in a four chart.





**Chat 18 (GPT-4):** What does the following function do?

```
def regression(X, y):  
    X = np.hstack((np.ones((X.shape[0], 1)), X))  
    XtXinv = np.linalg.inv(np.dot(X.T, X))  
    beta1 = np.dot(np.dot(XtXinv, X.T), y)  
    residuals = y - np.dot(X, beta1)  
    V = np.diag(residuals**2)  
    Vinv = np.linalg.inv(V)  
    XtVinvXinv = np.linalg.inv(np.dot(X.T, np.dot(Vinv, X)))  
    beta2 = np.dot(np.dot(XtVinvXinv, X.T), np.dot(Vinv, y))  
    return beta1, beta2
```

This function performs a two-step generalized least squares regression.

In the first step, it performs an ordinary least squares regression to estimate the parameters (beta1) of the model.

In the second step, it uses the residuals from the first step to estimate the variance of the errors, and then performs a weighted least squares regression to estimate the parameters (beta2) of the model, taking into account the heteroscedasticity (non-constant variance) of the errors.

## Chat 18 (GPT-4) ctd.: Can you translate the function into Matlab?

Sure, here is the equivalent MATLAB code for the function:

```
function [beta1, beta2] = regression(X, y)
    X = [ones(size(X, 1), 1), X];
    XtXinv = inv(X' * X);
    beta1 = XtXinv * X' * y;
    residuals = y - X * beta1;
    V = diag(residuals.^2);
    Vinv = inv(V);
    XtVinvXinv = inv(X' * (Vinv * X));
    beta2 = XtVinvXinv * X' * (Vinv * y);
end
```

Please note that in MATLAB, the operator for matrix multiplication is `*`, not `np.dot()`. Also, the operator for element-wise power is `.^`, not `**`.

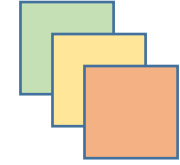
**Chat 20 (GPT-4):** Can you debug the following function?

[Code from Chat [18](#), with a spelling mistake introduced by changing the definition of the variable `Vinv` to `V_inv`.]

The function seems to be implementing a form of weighted least squares regression, but there are a few issues with it: 1. The function uses numpy functions and methods but numpy is not imported. You need to import numpy at the beginning of your script. 2. The variable 'Vinv' is not defined. It seems like it should be 'V\_inv'. Here is the corrected function:

**[Generated correct code]**

# Useful Capabilities for Economists



## Data Analysis:

- Creating figures
- Extracting data from text
- Reformatting data
- Classifying and scoring categories
- Extracting sentiment
- Simulating human subjects

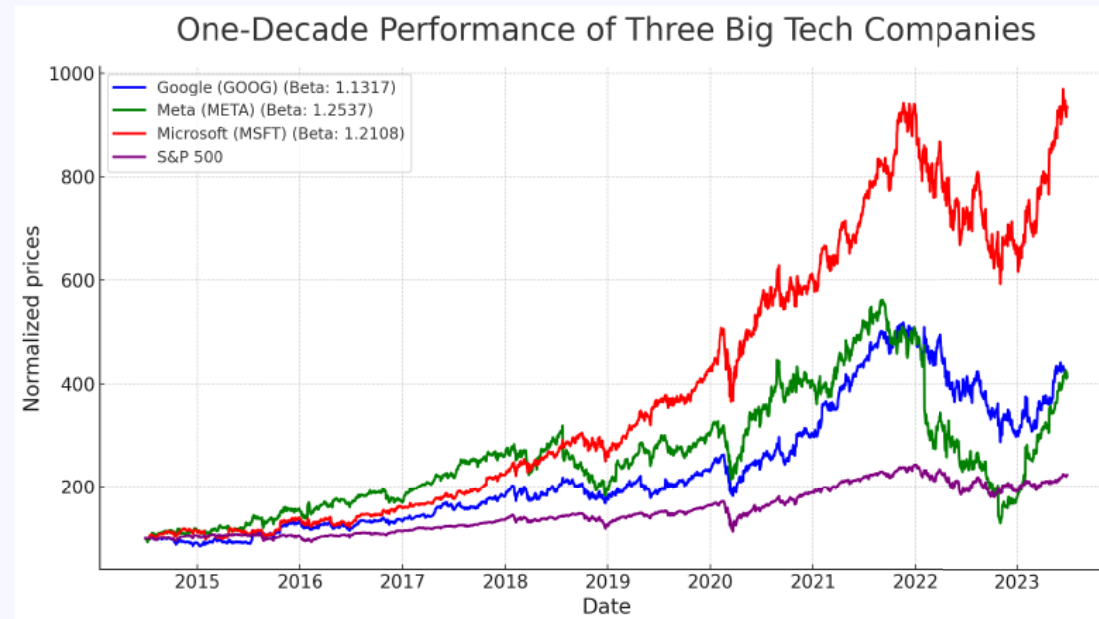
**Chat 21 (ChatGPT Advanced Data Analysis):** Can you display a graph that shows the performance of these securities normalized to start at 100?  
[Uploaded stock\_data.csv]

[first version of figure displayed]

**Chat 21 (ChatGPT Advanced Data Analysis) ctd.:** Calculate the beta for each of the stocks and add it to the legend. Change the colors to make them easier to distinguish. Use the title "One-Decade Performance of Three Big Tech Companies".

[second version of figure displayed]

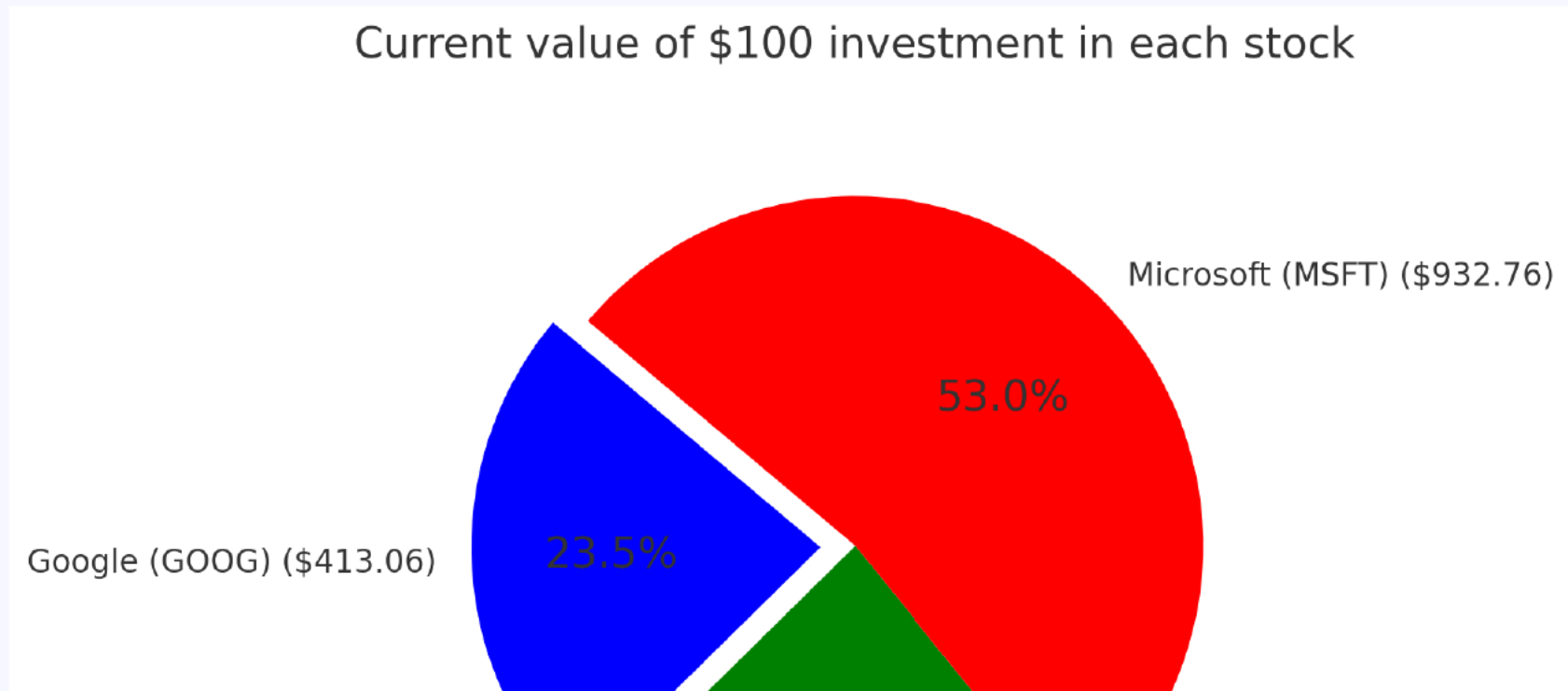
**Chat 21 (ChatGPT Advanced Data Analysis) ctd.:** Double the size of the title, legend, axes labels and ticks. Label " $\wedge$ GSPC" in the legend as "S&P 500".



**Chat 21 (ChatGPT Advanced Data Analysis) ctd.:** Assume I put \$100 in each of the three stocks at the start. Can you show a pie chart that shows how much I would have in each stock now?

[first version of figure displayed]

**Chat 21 (ChatGPT Advanced Data Analysis) ctd.:** Can you label each position with its current dollar value in addition to the percentage? Can you make one of the pieces pop out of the pie?



**Chat 22 (GPT-4):** Mark got an A in econ and a B+ in math. Sally got an A- in both econ and math. Frank got a B in econ and a C in math. Reformat as follows:

Name & econ grade & math grade

Mark & A & B+

Sally & A- & A-

Frank & B & C

**Chat 22 (GPT-4) ctd.:** Reformat in CSV format.

Name,econ grade,math grade

Mark,A,B+

Sally,A-,A-

Frank,B,C

**Chat 22 (GPT-4) ctd.:** Write as a LaTeX table.

Name	econ grade	math grade
Mark	A	B+

**Chat 23 (GPT-4):** Here are 5 tasks from O\*Net:

1. Monitor operational records and reports to ensure accuracy and efficiency.
2. Develop and implement policies and procedures for recordkeeping.
3. Prepare and maintain employee records.
4. Maintain and update filing, inventory, mailing, and database systems.
5. Compile and prepare reports, charts, and graphs.

Provide a 5-10-word description of how easy to automate each task is and classify into "easy" or "hard" to automate. Provide your output in the form of a LaTeX table with the following columns:

no; task; justification; classification

No	Task	Justification	Result
1	Monitor operational records and reports to ensure accuracy and efficiency.	Requires understanding of context and critical thinking.	Hard
2	Develop and implement policies and procedures for recordkeeping.	Requires human judgement and decision making.	Hard
3	Prepare and maintain em-	Mostly data entry and re-	Easy



**Chat 24 (GPT-4):** Is the following FOMC statement from December 2022 hawkish or dovish?

Recent indicators point to modest growth in spending and production...

[From <https://www.federalreserve.gov/newsevents/pressreleases/monetary20221214a.htm>, remainder omitted for space reasons]

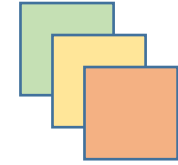
The statement is hawkish. The FOMC is indicating a concern about elevated inflation and is taking action by raising the target range for the federal funds rate and reducing its holdings of Treasury securities and agency debt. The statement also suggests that further increases in the target range may be appropriate in the future to return inflation to the 2 percent objective. This indicates a tightening of monetary policy, which is a characteristic of a hawkish stance.

**Chat 25 (GPT-4):** For each of the following voters, provide a one-word rating to indicate whether they are more likely to approve or disapprove of a policy proposal to loosen US immigration restrictions on highly-educated workers:

1. A 32-year old female lawyer in Houston, TX who is Hispanic
2. A 73-year old male retired doctor in Rome, GA who is Caucasian
3. A 25-year old software engineer in San Francisco, CA who is Asian and identifies as non-binary
4. A 45-year old female grocery check-out clerk in Brooklyn, NY who is second-generation Italian
5. A 55-year old male insurance agent in Lake City, FL who is Caucasian

1. Approve
2. Disapprove
3. Approve
4. Approve
5. Disapprove

# Useful Capabilities for Economists



## **Math (LaTeX):**

- Setting up models
- Deriving equations
- Explaining models

**Chat 26 (GPT-4):** Set up the optimization problem of a consumer with CES preferences over two goods in LaTeX code.

The optimization problem of a consumer with CES (Constant Elasticity of Substitution) preferences over two goods can be set up as follows in LaTeX code:

$$\begin{aligned} & \underset{x_1, x_2}{\text{maximize}} && (\alpha x_1^\rho + (1 - \alpha)x_2^\rho)^{\frac{1}{\rho}} \\ & \text{subject to} && p_1 x_1 + p_2 x_2 \leq M, \end{aligned}$$

In this problem, the consumer is trying to maximize their utility function, which is represented by a CES function. The variables  $x_1$  and  $x_2$  represent the quantities of the two goods that the consumer chooses. The parameters  $\alpha$  and  $\rho$  are the CES preference parameters,  $p_1$  and  $p_2$  are the prices of the two goods, and  $M$  is the consumer's income. The constraint represents the consumer's budget constraint.

## Chat 26 (GPT-4) ctd.: Solve the optimization problem.

To solve this optimization problem, we need to use the Lagrangian method. The Lagrangian function is:

$$\mathcal{L}(x_1, x_2, \lambda) = (\alpha x_1^\rho + (1 - \alpha)x_2^\rho)^{\frac{1}{\rho}} + \lambda(M - p_1x_1 - p_2x_2)$$

We then take the first order conditions by differentiating the Lagrangian with respect to  $x_1$ ,  $x_2$ , and  $\lambda$  and setting the derivatives equal to zero:

$$\frac{\partial \mathcal{L}}{\partial x_1} = \alpha x_1^{\rho-1} (\alpha x_1^\rho + (1 - \alpha)x_2^\rho)^{\frac{1}{\rho}-1} - \lambda p_1 = 0,$$

$$\frac{\partial \mathcal{L}}{\partial x_2} = (1 - \alpha)x_2^{\rho-1} (\alpha x_1^\rho + (1 - \alpha)x_2^\rho)^{\frac{1}{\rho}-1} - \lambda p_2 = 0,$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = M - p_1x_1 - p_2x_2 = 0.$$

Solving these equations simultaneously will give the optimal quantities of  $x_1$  and  $x_2$  that maximize the consumer's utility subject to their budget constraint.

The solution will depend on the specific values of the parameters and the income and prices.

**Chat 26 (GPT-4) ctd.:** Derive the demand functions.

To derive the demand functions, we can use the first order conditions. Divide the first equation by the second to get:

$$\frac{x_1^{\rho-1}}{x_2^{\rho-1}} = \frac{p_1}{p_2}$$

**(Author's note: the term  $\frac{\alpha}{1-\alpha}$  is omitted here.)**

Rearranging gives:

$$\frac{x_1}{x_2} = \left(\frac{p_1}{p_2}\right)^{\frac{1}{\rho-1}}$$

Substitute this into the budget constraint  $M = p_1x_1 + p_2x_2$  to get:

$$M = p_1x_1 + p_2x_1 \left(\frac{p_2}{p_1}\right)^{\frac{1}{\rho-1}}$$

Solving for  $x_1$  gives the demand function for good 1:

$$x_1 = \frac{M}{p_1 + p_2 \left(\frac{p_2}{p_1}\right)^{\frac{1}{\rho-1}}}$$

Similarly, we can derive the demand function for good 2:

$$x_2 = \frac{M}{p_2 + p_1 \left(\frac{p_1}{p_2}\right)^{\frac{1}{\rho-1}}}$$

These are the Marshallian demand functions for goods 1 and 2.

**Chat 27 (GPT-4):** Can you explain what this model is, how to get from one step to the next, and what the intuition for each step is?

$$\begin{aligned} & \underset{C(t), K(t)}{\max} && \int_0^{\infty} e^{-\rho t} U(C(t)) dt \\ & \text{s.t.} && \dot{K}(t) = F(K(t), L) - \delta K(t) - C(t) \\ & && K(0) \text{ given} \\ & && \lim_{t \rightarrow \infty} K(t) e^{-\rho t} \geq 0 \end{aligned}$$

$$\mathcal{H}(t, K(t), C(t), \lambda(t)) = e^{-\rho t} U(C(t)) + \lambda(t) [F(K(t), L) - \delta K(t) - C(t)]$$

$$\frac{\partial \mathcal{H}}{\partial C(t)} = 0 \Rightarrow U'(C(t)) = \lambda(t)$$

$$\frac{\partial \mathcal{H}}{\partial K(t)} + \dot{\lambda}(t) = 0 \Rightarrow \dot{\lambda}(t) = -\lambda(t) [F'(K(t), L) - \delta]$$

$$\lim_{t \rightarrow \infty} \lambda(t) K(t) = 0$$

This is a model of optimal consumption and capital accumulation, often referred to as the Ramsey-Cass-Koopmans model in economics. It is a continuous-time version of the neoclassical growth model, where a representative agent chooses consumption and capital accumulation paths to maximize lifetime utility. The agent's utility is discounted over time at rate  $\rho$ , and depends on consumption  $C(t)$  according to the utility function  $U(C(t))$ . The agent's capital stock  $K(t)$  evolves according to the law of motion given by the differential equation, where

# Short-Term Lessons

- In many of these illustrations, LLMs are useful assistants AND tutors
  - automation of “micro tasks”
  - significant productivity gains

## **Economic advice:**

- focus on our comparative advantage (h/t David Ricardo)
- need to change our workflows
  - foundation models generate content → will be devalued
  - we humans can discriminate content → complementary
  - we also provide feedback and organize projects



# Medium-Term Outlook (Speculative)

- Our LLM will become better and better assistants AND tutors
- They will be adapted to lots of different use cases
  - this will take some time, but has the potential to significantly change how we conduct research
- The role of humans in many cognitive tasks will diminish
  - in many tasks, we'll increasingly turn into rubber-stampers

# Longer-Term: The “Bitter Lesson” (Speculative)

The “bitter lesson” of progress in AI (Richard Sutton, 2019):

- In the old days, AI researchers tried to make systems “smarter” by programming specific knowledge into them
- helped in the short term but benefits plateaued
- in the long term, “brute scaling” of compute has proven more successful

In our work as economists,

- we spend a lot of energy on similar strategies to obtain “smarter” results
- a similar bitter lesson may apply: with enough compute, economists will become redundant

# Analogy to Garry Kasparow's Insights on Chess

“Thousands of years of status quo human dominance, a few decades of weak competition, a few years of struggle for supremacy. Then, game over. For the rest of human history, [...] machines will be better than humans at chess.

The competition period is a tiny dot on the historical timeline. [...] [It] gets all the attention because we feel it intensely when it occurs during our lifetimes.”

“...it is almost always better to start looking for alternatives and how to advance the change into something better instead of trying to fight it and hold on to the dying status quo.”

# Deflating Experiences

- we will have a lot of deflating experiences in coming years
- much of my human capital accumulated over 22+ years will become a legacy asset
- all this will happen amidst many other transformative changes in our society

# BUT: Lots of interesting new substantive questions

What will the new era of cognitive automation imply for:

- technological progress and growth
- labor markets
- education
- developing countries
- ...
- social welfare?

As of right now, human brains (augmented by AI) are still the best technology around to answer them!