1989
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Image prompt (Midjourney): Illustrate a complex transportation system with autonomous vehicles, electrification. More futuristic trucks, less passenger cars. Abstract visualization of digital communication with the vehicles. charcoal sketch --ar 16:9

Embracing complexity in transportation systems - the next 100 years

Per Olof Arnäs, PhD

Hi! My name is Per Olof Arnäs.

- MSc Mechanical engineering, Chalmers 1996
- PhD in logistics 2007
- Working with and in the haulage industry since 1988
  - Consultant/developer 1998-2002
  - Full time expert, developer, R&D (TRB Sverige) 2003-2010, finished PhD during
- Chalmers 2011-2020
  - Senior lecturer/researcher
  - Vice head of department (education) at Technology Management and Economics 2018-2020
- Director Logistics Strategy at Einride 2021-2023
- Podcaster

- Given some spare time, I tend to build things that you can cook in or with.

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I love the 21st century

1896
First truck
(Daimler)

1500 kg payload

Roads were low quality

Very slow market uptake

1896
First truck
(Daimler)

A lot of innovation

Easter morning 1900: 5th Ave, New York City. Spot the automobile.

Source: US National Archives

Easter morning 1913: 5th Ave, New York City. Spot the horse.

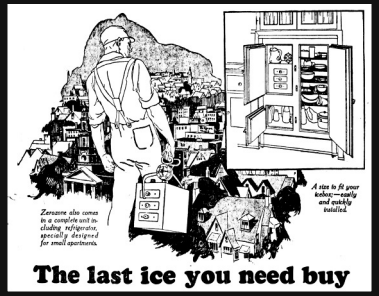
Source: George Grantham Bain Collection.

1920-30
Trucks
disrupt
horses

1896
First
truck

A lot of innovation

1910
Ice delivery



1923

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1896
First
truck

1920-30
Trucks
disrupt
horses

A lot of innovation

Trucks take over land based freight

Production and sourcing could be located almost anywhere

Many roads taken over by government

Unprecedented growth

1896
First
truck

1920-30
Trucks
disrupt
horses

1956
Containers
disrupt global
trade

A lot of innovation

Trucks take over land based freight

Huge economies of scale

Distance less important

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A global transportation network emerges

Still administered using analog technology

1896
First
truck

1920-30
Trucks
disrupt
horses

1956
Containers
disrupt global
trade

A lot of innovation

Trucks take over land based freight

Globalization
commences

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1990s
Computers

1920-30
Trucks
disrupt
horses

1896
First
truck

1956
Containers
disrupt global
trade

A lot of innovation

Trucks take over land based freight

Globalization
commences

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1896
First
truck

1920-30
Trucks
disrupt
horses

1956
Containers
disrupt global
trade

1990s
Computers

The era of Spreadsheets

Path of least resistance

A lot of innovation

Trucks take over land based freight

Globalization commences

Transport industry is computerized but not disrupted

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Make complex decisions

Learn

Recommend

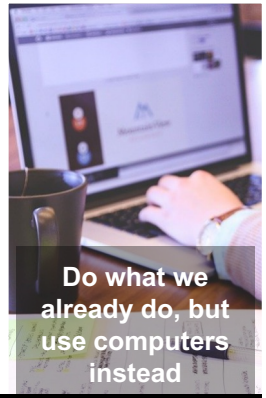
Predict

AI

Digitalization

Digitization

Computerization



Do what we already do, but use computers instead

Make analogue information digital

Use digital technology to do new things

Use digital technology to do things that were previously **impossible**

1896
First
truck

1920-30
Trucks
disrupt
horses

1956
Containers
disrupt global
trade

1990s
Computers

Gamechanger

2020s
Electric
trucks

A lot of innovation

Trucks take over land based freight

Globalization
commences

Transport
industry is
computerized
but not disrupted

Towards digital,
electric and
highly automated

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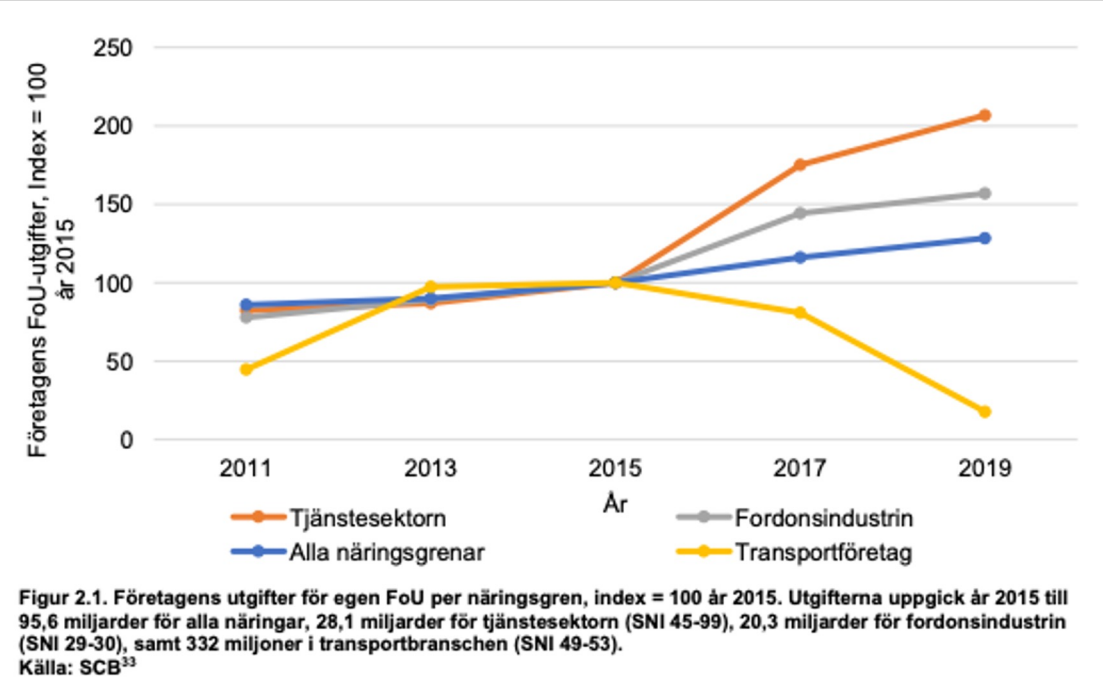
Crisis in the transport industry

R&D spending 2011-2019 by industry (Sweden)



Figur 2.1. Företagens utgifter för egen FoU per näringsgren, index = 100 år 2015. Utgifterna uppgick år 2015 till 95,6 miljarder för alla näringar, 28,1 miljarder för tjänstesektorn (SNI 45-99), 20,3 miljarder för fordonsindustrin (SNI 29-30), samt 332 miljoner i transportbranschen (SNI 49-53).
Källa: SCB[33]

Compared to 2015

- **All industries together increased 25%**
- **Services by 200%**
- **Automotive by 150%**
- **Transport down 80%!**

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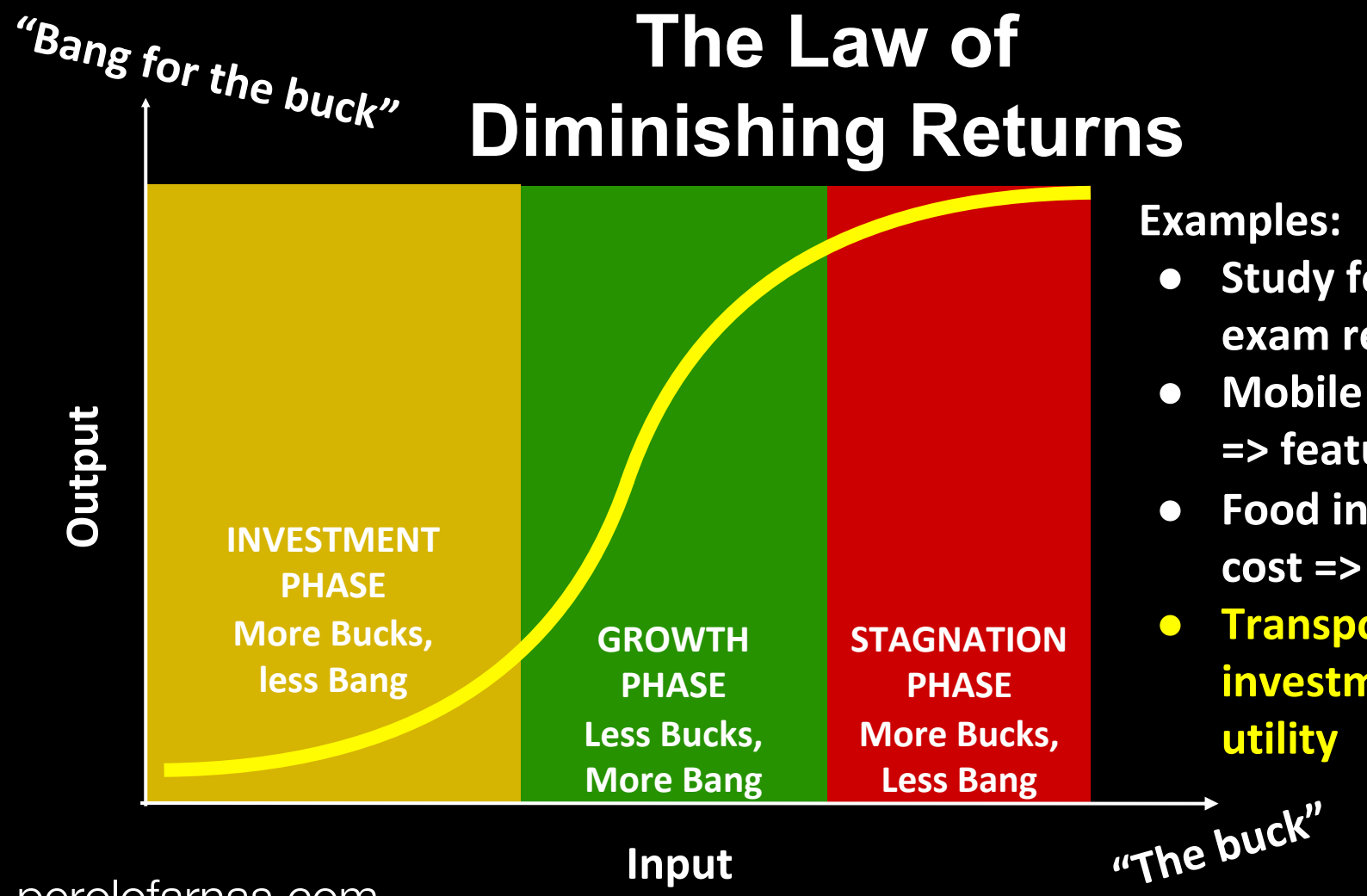
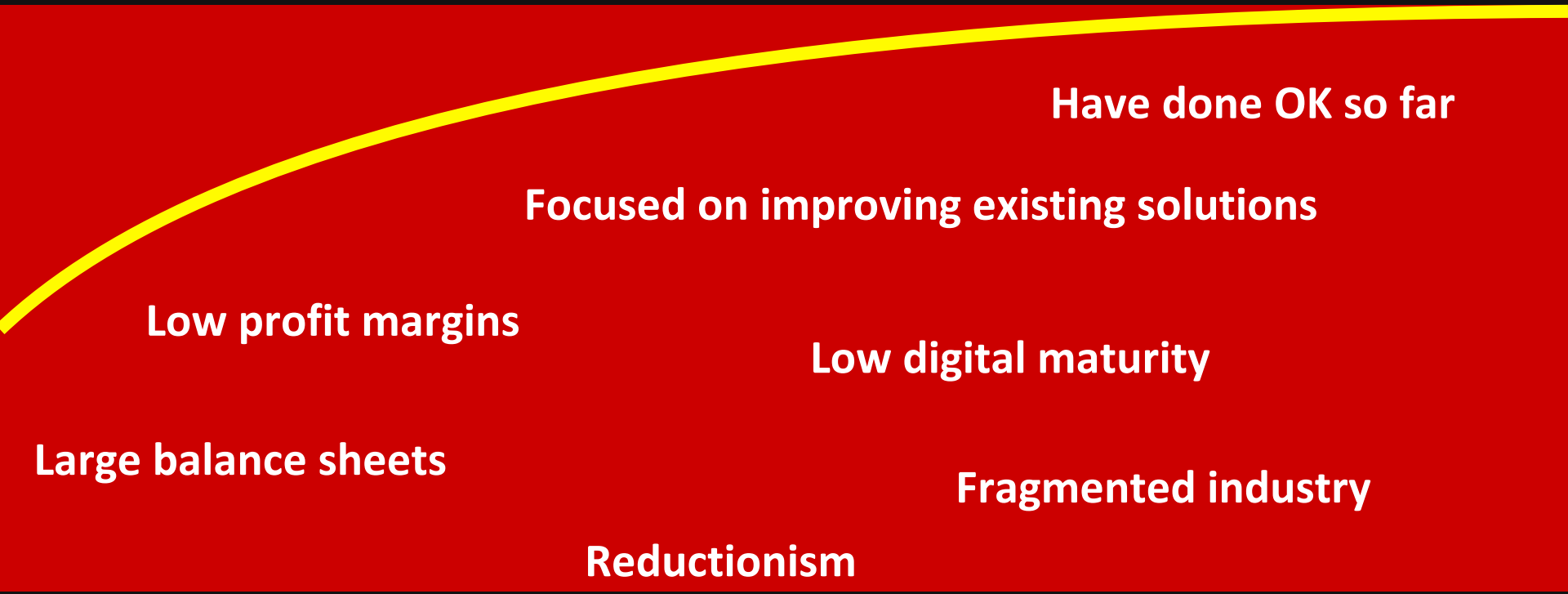
The Law of Diminishing Returns



Examples:

- Study for exam => exam result
- Mobile phone cost => features
- Food ingredient cost => tastiness
- **Transport industry investments => utility**

Stagnation of the transport industry - some of the reasons



Planning for ICE truck

Planning for BE truck

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Planning for ICE fleet

Maximise paid tonne-km
Minimise cost

Scaling by Copy-Paste

Planning for BE fleet

Maximise paid tonne-km
Minimise cost

Each transport is unique

Sweet-spot flows a minority

Charging investment

Increased complexity when scaling

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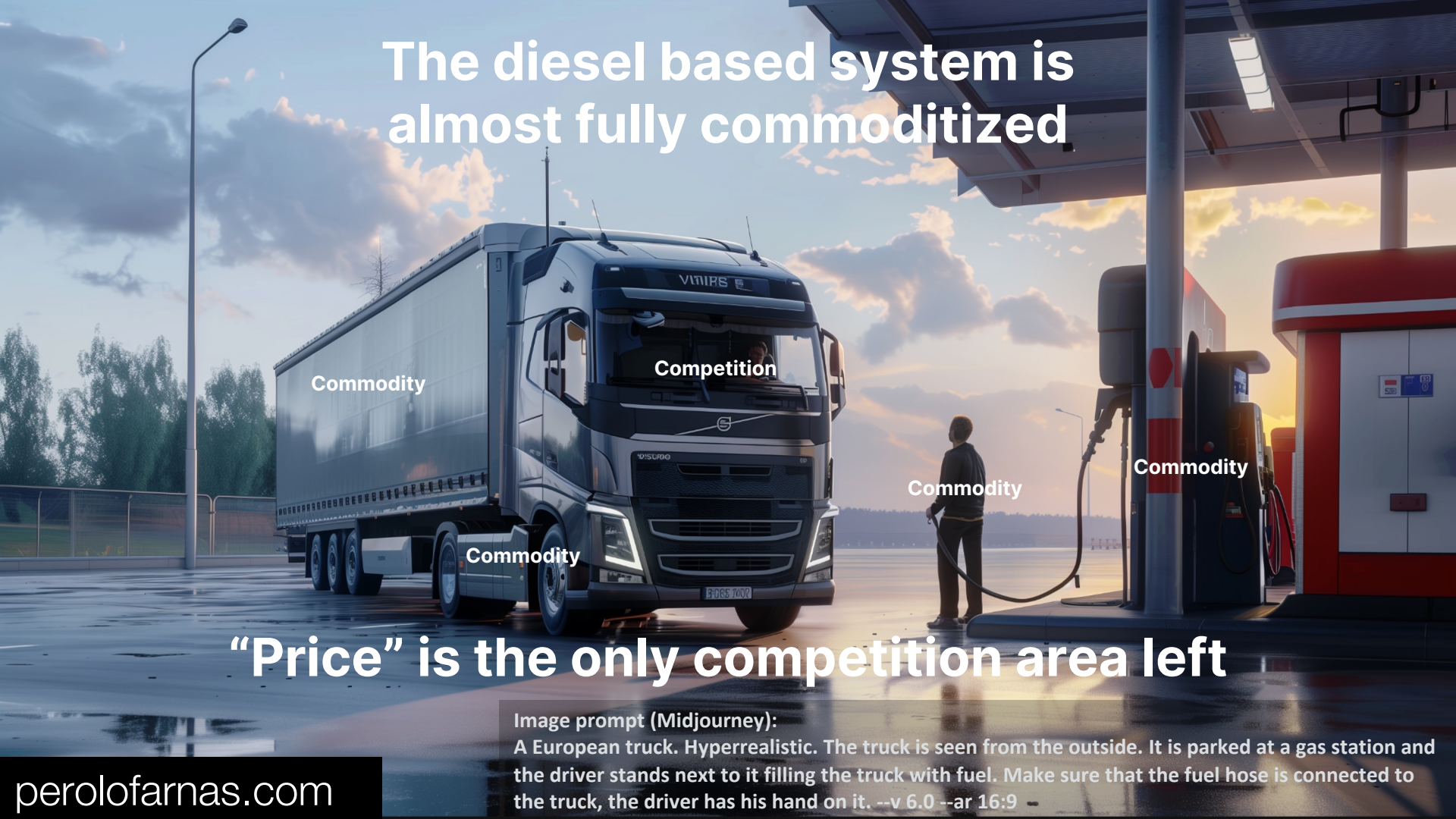
The diesel based system is almost fully commoditized



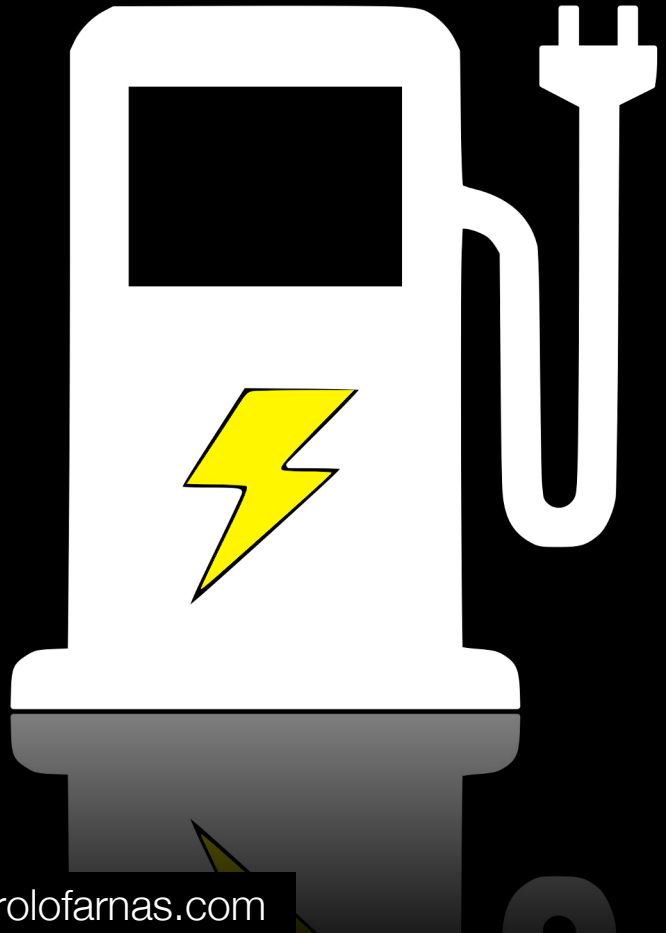
“Price” is the only competition area left

Image prompt (Midjourney):
A European truck. Hyperrealistic. The truck is seen from the outside. It is parked at a gas station and the driver stands next to it filling the truck with fuel. Make sure that the fuel hose is connected to the truck, the driver has his hand on it. --v 6.0 --ar 16:9

In the electric system almost nothing is a commodity

Image prompt (Midjourney):
A European electric truck. Hyperrealistic. The truck is seen from the outside. It is parked at a charging station and the driver stands next to it charging the truck with electricity. Make sure that the charging cable is connected to the truck, the driver has his hand on it. --v 6.0 --ar 16:9

Will Heavy Electric Vehicles Be Profitable?



YES!

Before 2025-2030, sooner with subsidies

Frequent use/ high utilisation rate

Even use, same time/distance most days

Charge at "home" during night

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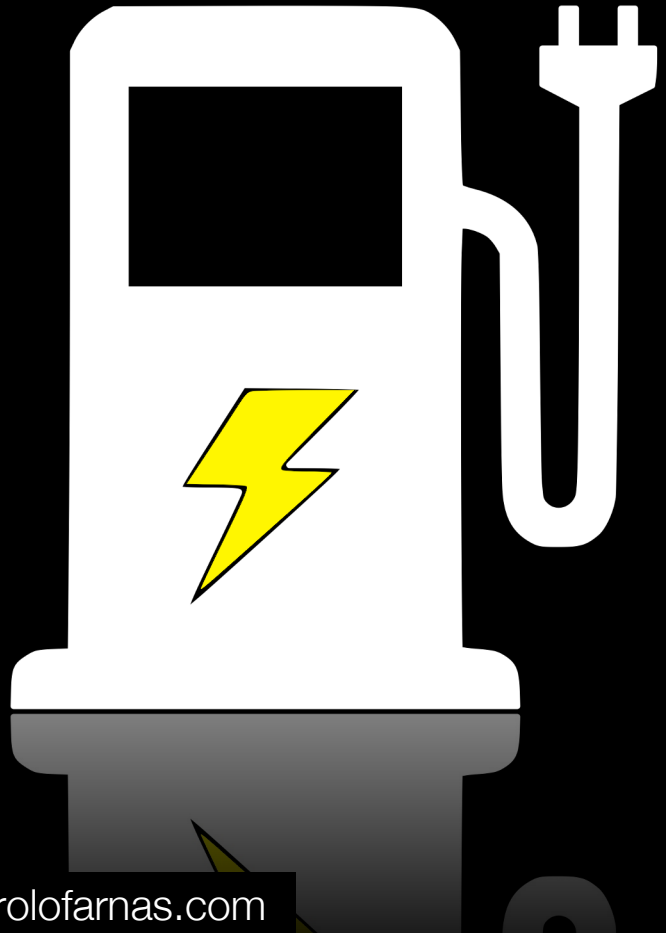
Source: Anders Grauers, Chalmers University, Nov 2020

Will Heavy Electric Vehicles Be Profitable?



YES!

- **Before 2025-2030**, sooner with subsidies
- **Frequent use**/ high utilisation rate
- **Even use**, same time/distance most days
- **Charge at "home"** during night

Life Cycle **Cost lower than diesel** truck

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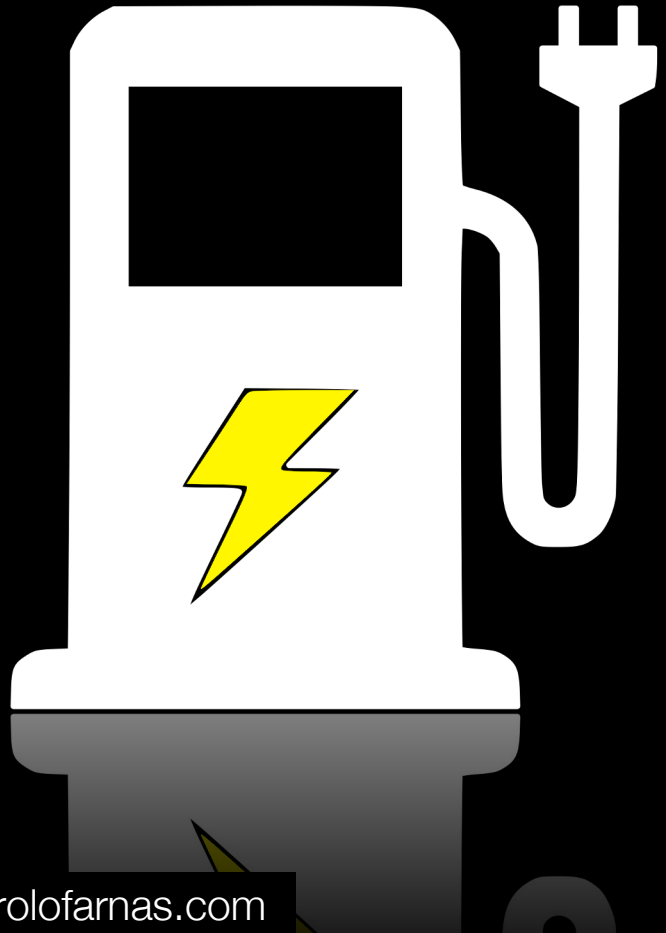
Source: Anders Grauers, Chalmers University, Nov 2020

Will Heavy Electric Vehicles Be Profitable?



YES!

- **Before 2025-2030**, sooner with subsidies
- **Frequent use**/ high utilisation rate
- **Even use**, same time/distance most days
- **Charge at "home"** during night

This requires digital decision support

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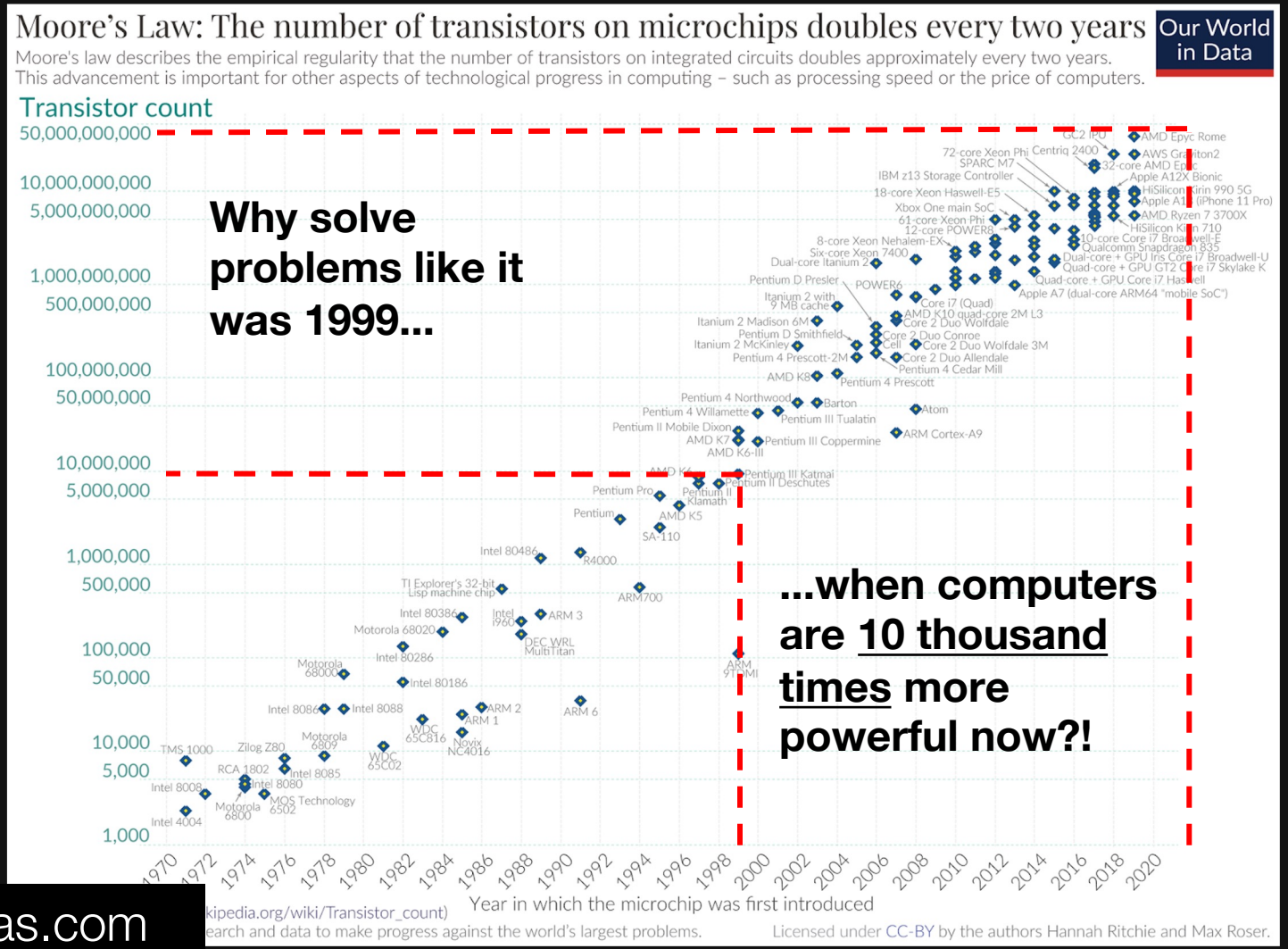
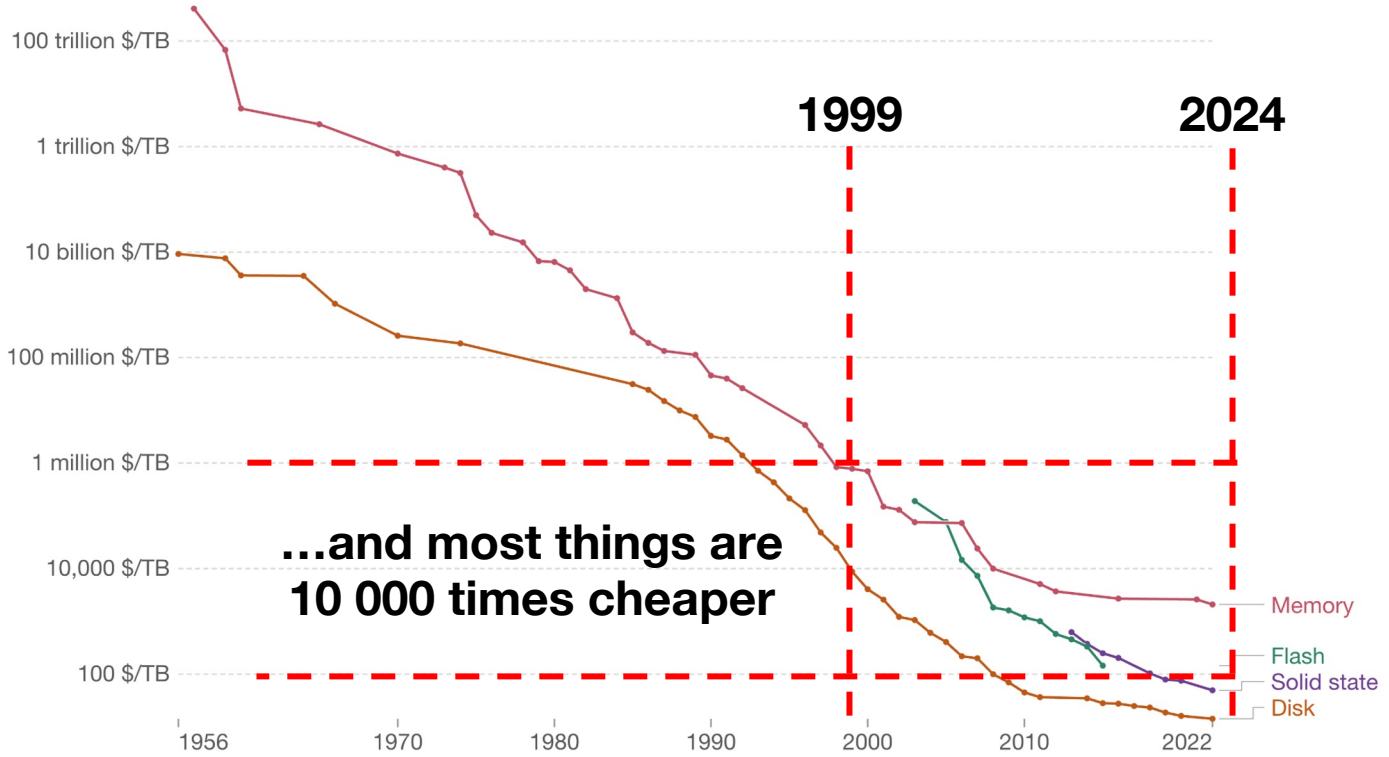
Source: Anders Grauers, Chalmers University, Nov 2020


Moore's Law: The number of transistors on microchips doubles 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.
Our World in Data
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
5,000
1,000
Why solve problems like it was 1999...
...when computers are 10 thousand times more powerful now?!
Intel 4004
Intel 8008
TMS 1000
Intel 8080
Motorola 6800
MOS Technology 6502
RCA 1802
Zilog Z80
Intel 8085
Motorola 6809
Intel 8086
Intel 8088
Intel 80186
Intel 80286
Motorola 68000
Motorola 68020
Intel 80386
Intel i960
ARM 3
DEC WRL MultiTitan
ARM 1
ARM 2
WDC 65C816
WDC 65C02
Novix NC4016
ARM 6
TI Explorer's 32-bit Lisp machine chip
Intel 80486
R4000
ARM700
ARM 9TDMI
Pentium
AMD K5
SA-110
Pentium Pro
Pentium II Klamath
Pentium II Deschutes
AMD K6
Pentium III Katmai
AMD K6-III
Pentium III Coppermine
Pentium II Mobile Dixon
AMD K7
Pentium III Tualatin
Pentium 4 Willamette
Pentium 4 Northwood
Barton
Atom
ARM Cortex-A9
AMD K8
Pentium 4 Prescott
Pentium 4 Cedar Mill
Pentium 4 Prescott-2M
Core 2 Duo Allendale
Itanium 2 McKinley
Core 2 Duo Wolfdale 3M
Pentium D Smithfield
Cell
Core 2 Duo Conroe
Itanium 2 Madison 6M
Core 2 Duo Wolfdale
AMD K10 quad-core 2M L3
Itanium 2 with 9 MB cache
Core i7 (Quad)
POWER6
Pentium D Presler
Dual-core Itanium 2
Apple A7 (dual-core ARM64 "mobile SoC")
Quad-core + GPU Core i7 Haswell
Quad-core + GPU GT2 Core i7 Skylake K
Dual-core + GPU Iris Core i7 Broadwell-U
Qualcomm Snapdragon 835
10-core Core i7 Broadwell-E
HiSilicon Kirin 710
12-core POWER8
61-core Xeon Phi
Xbox One main SoC
18-core Xeon Haswell-E5
AMD Ryzen 7 3700X
Apple A13 (iPhone 11 Pro)
HiSilicon Kirin 990 5G
Apple A12X Bionic
IBM z13 Storage Controller
SPARC M7
32-core AMD Epyc
AWS Graviton2
72-core Xeon Phi
Centriq 2400
AMD Epyc Rome
GC2 IPU
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year in which the microchip was first introduced
kipedia.org/wiki/Transistor_count)
earch and data to make progress against the world's largest problems.
Licensed under CC-BY by the authors Hannah Ritchie and Max Roser.

Historical cost of computer memory and storage

This data is expressed in US dollars per terabyte (TB). It is not adjusted for inflation.

Our World in Data



Data source: John C. McCallum (2022)

OurWorldInData.org/technological-change | CC BY

Note: For each year, the time series shows the cheapest historical price recorded until that year.

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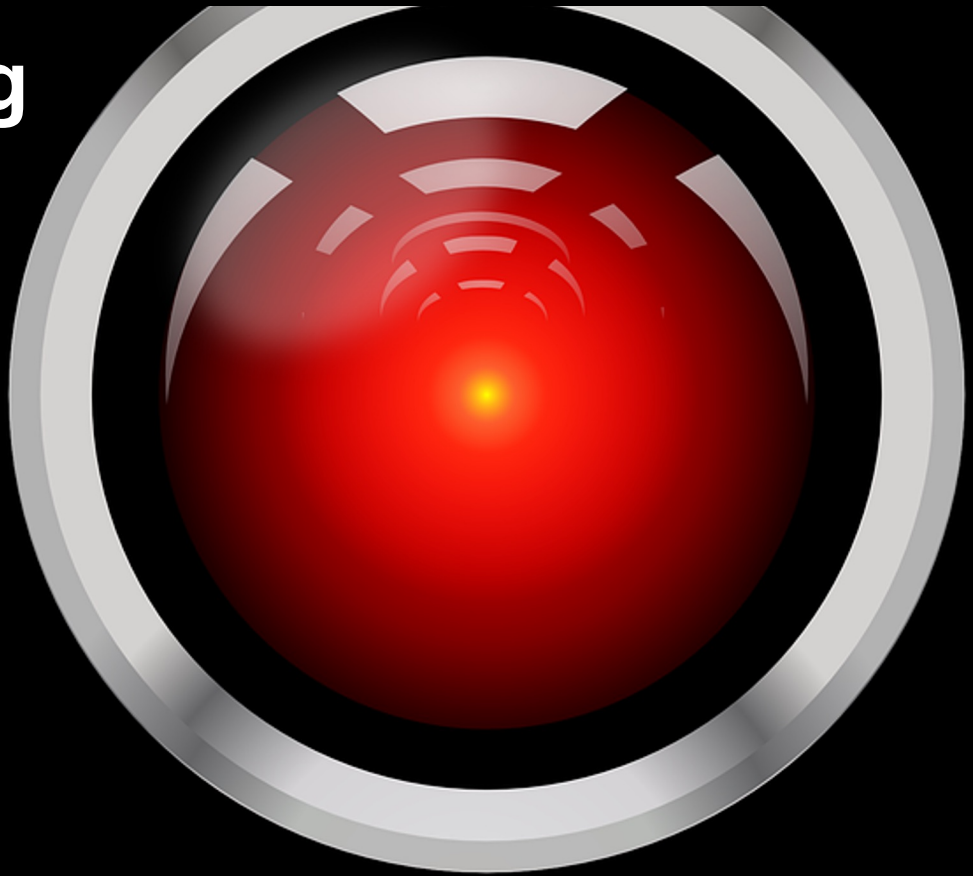
Artificial intelligence

Reasoning

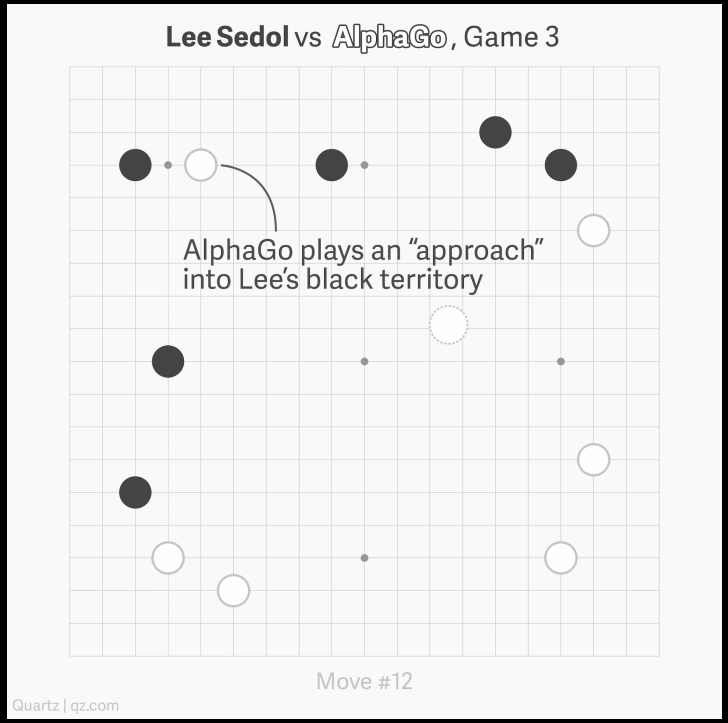
Learning



Problem solving

Creating

Specialised AI



General AI

Superior to humans

Large data sets

Identify abstract patterns and trends

Control large systems

Recommendations and decision support

Generating content

Optimisation

Model
GPT-4

ChatGPT PLUS

GPT-4 currently has a cap of 25 messages every 3 hours.

Please write a script that prompts me for an image and then displays the location the image was taken on a map.

ChatGPT Mar 23 Version. ChatGPT may produce inaccurate information about people, places, or facts.

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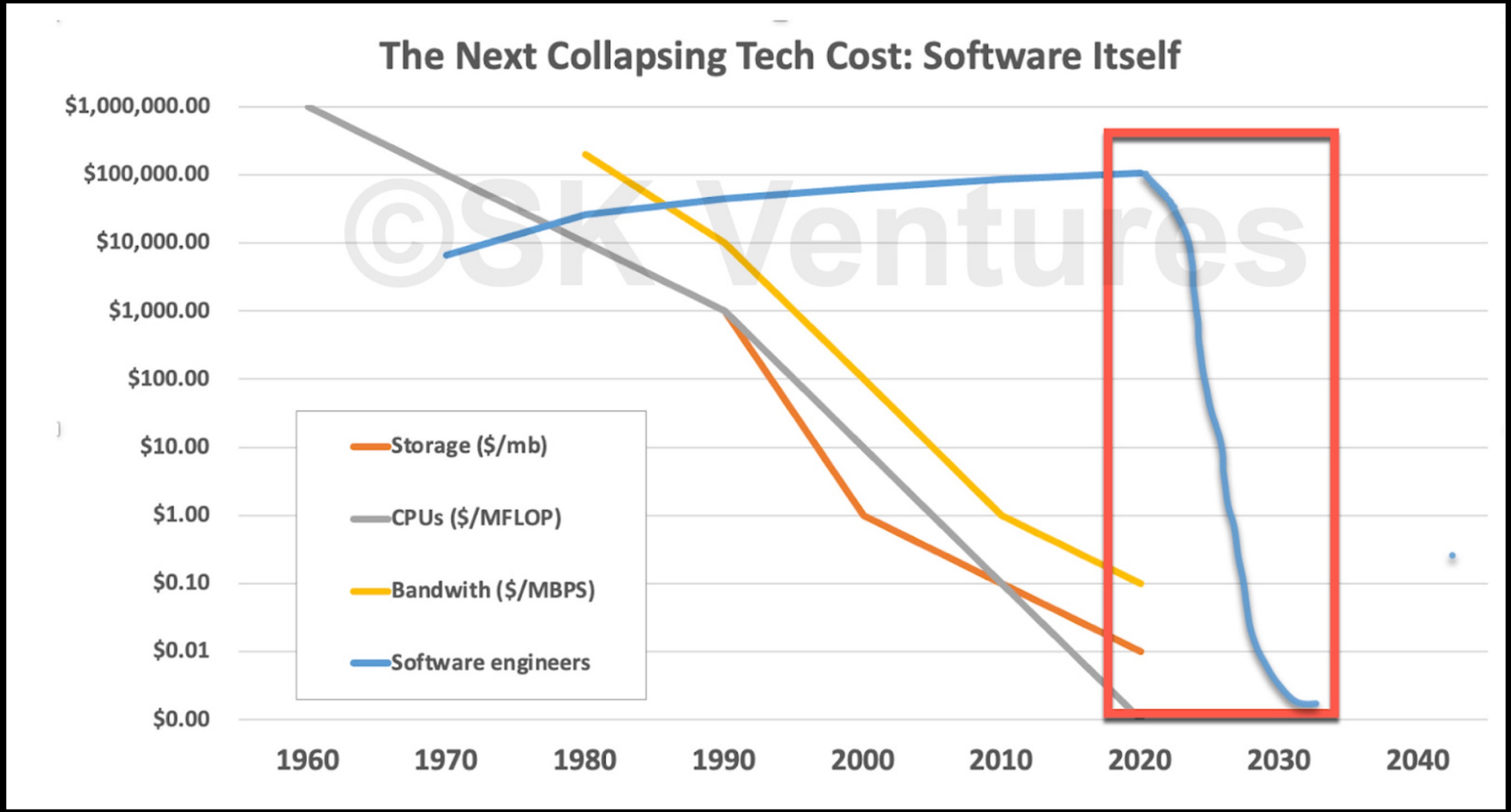
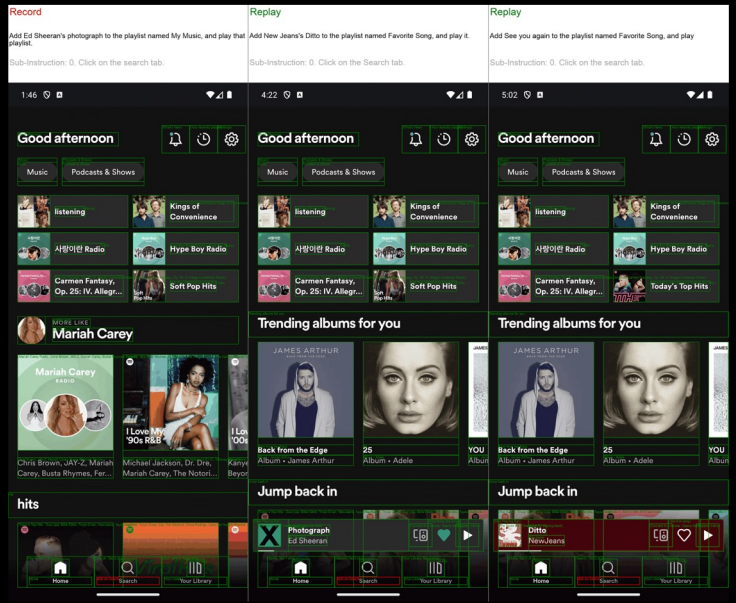


https://skventures.substack.com/p/societys-technical-debt-and-softwares

Please help me start an online business. I want to increase my net worth.

Large Action Models (LAM)



Reinforcement Learning

When the AI learns by doing

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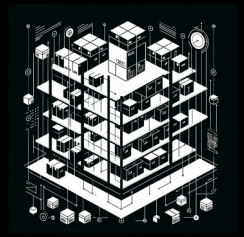
Image prompt (Midjourney): Two robots playing chess in a cafeteria

Some applications of RL

Routing

Customer contact



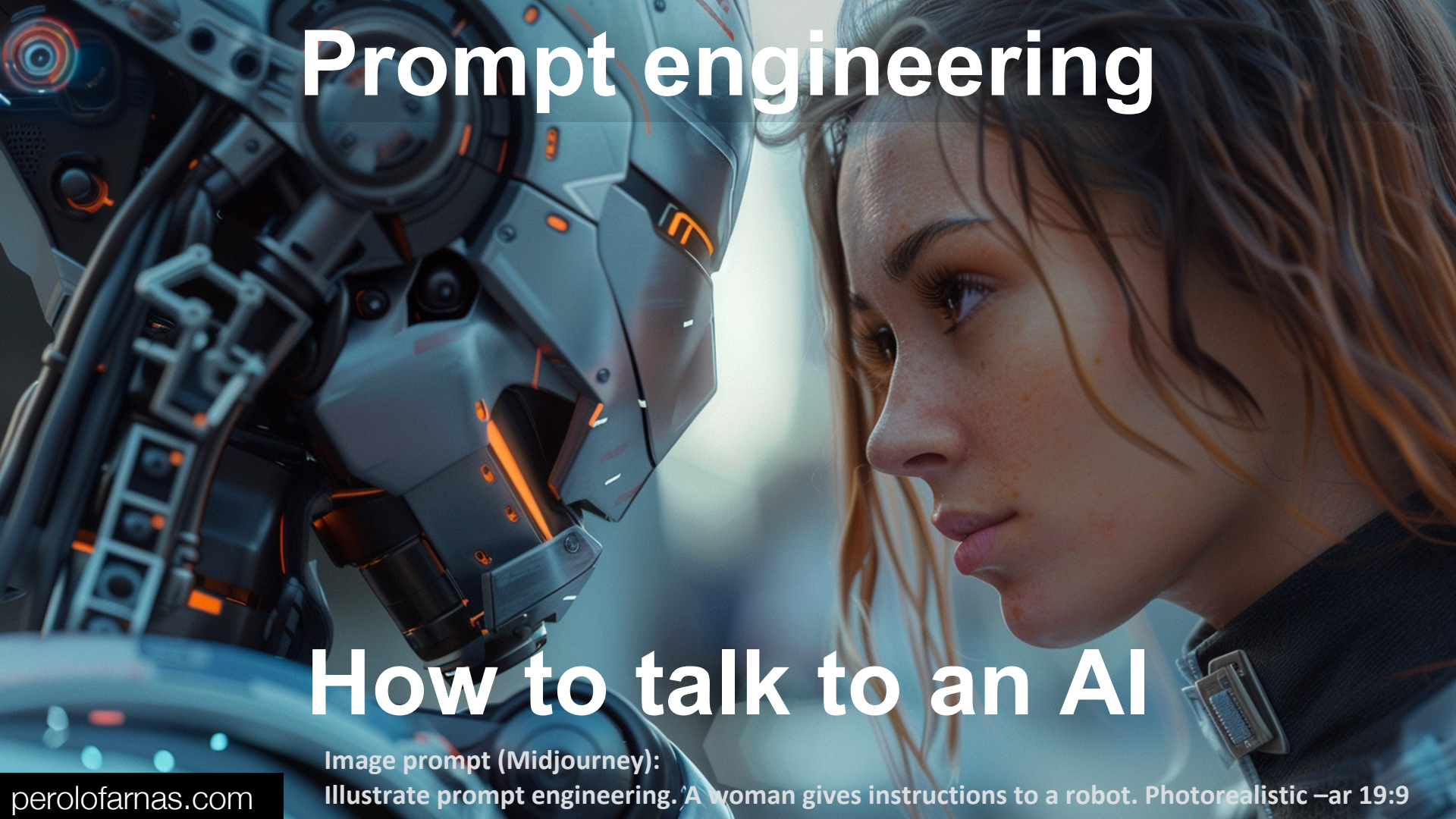
Inventory management

Forecasting

Pricing

Scheduling

Prompt engineering



How to talk to an AI

Image prompt (Midjourney):
Illustrate prompt engineering. A woman gives instructions to a robot. Photorealistic –ar 19:9

Figure - Humanoid robots

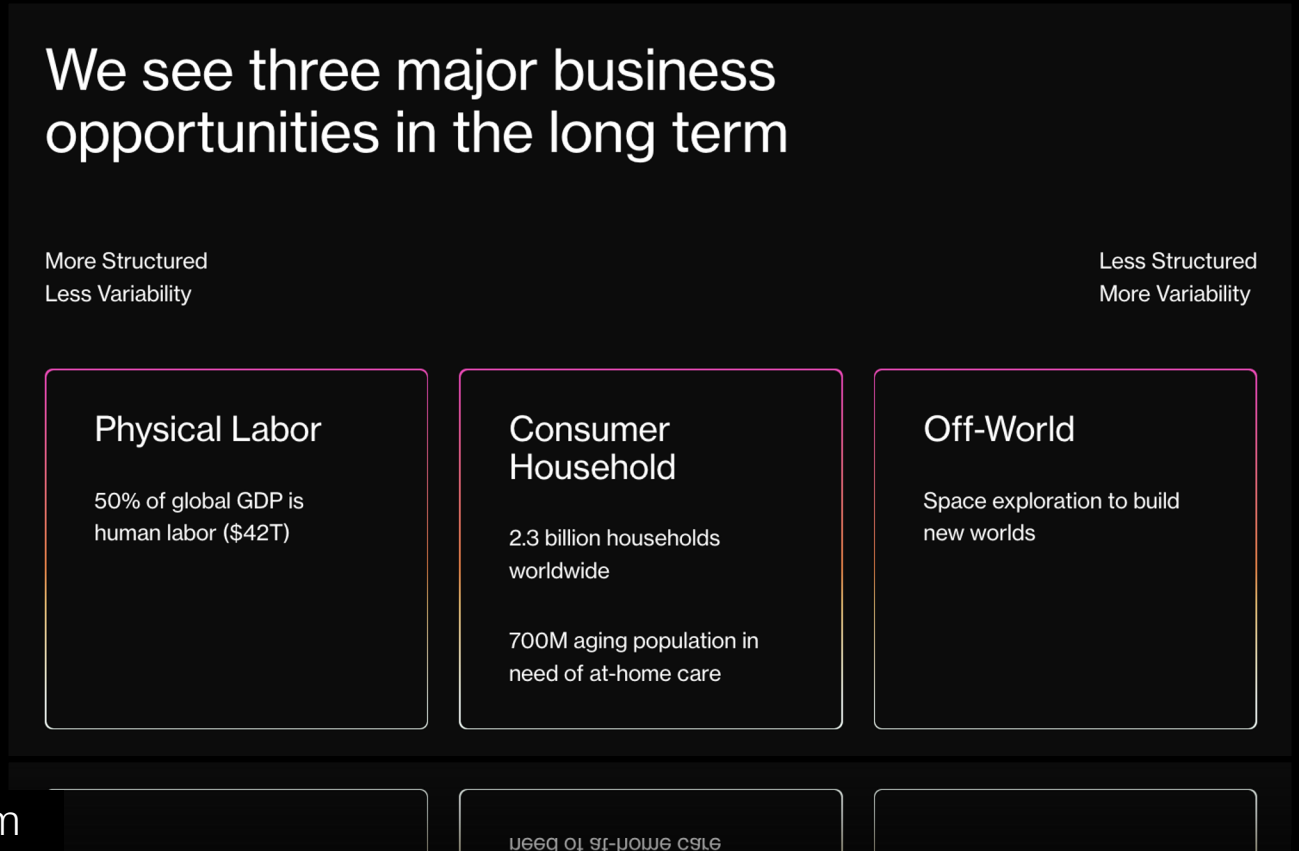


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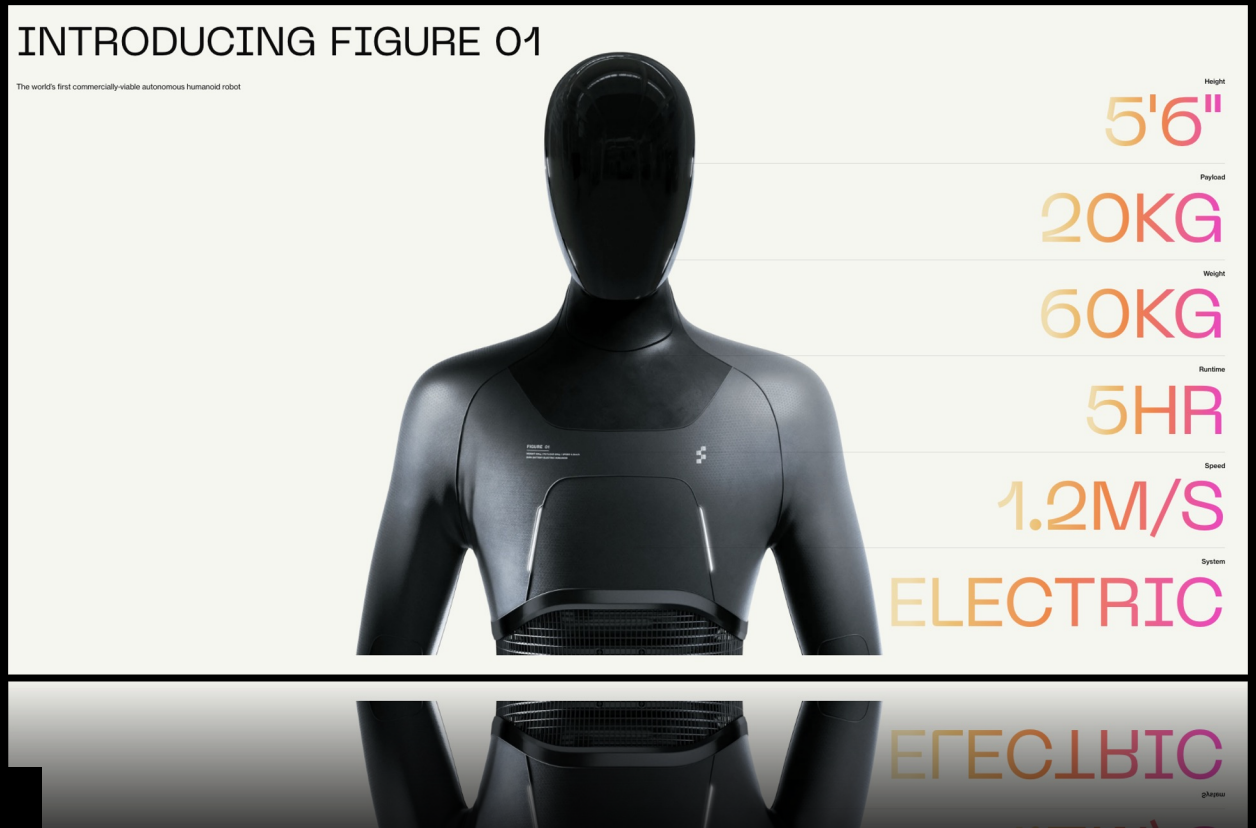
Figure - Humanoid robots



New colleagues

Image prompt (Midjourney):
photorealistic image of two humanoid robots drinking engine oil at a coffee table in the lunch room at a factory, an old style tin oil can is resting on the table between the robots. The text OIL is visible on the can. At another table there are human factory workers drinking coffee. --v 6.0 --ar 16:9

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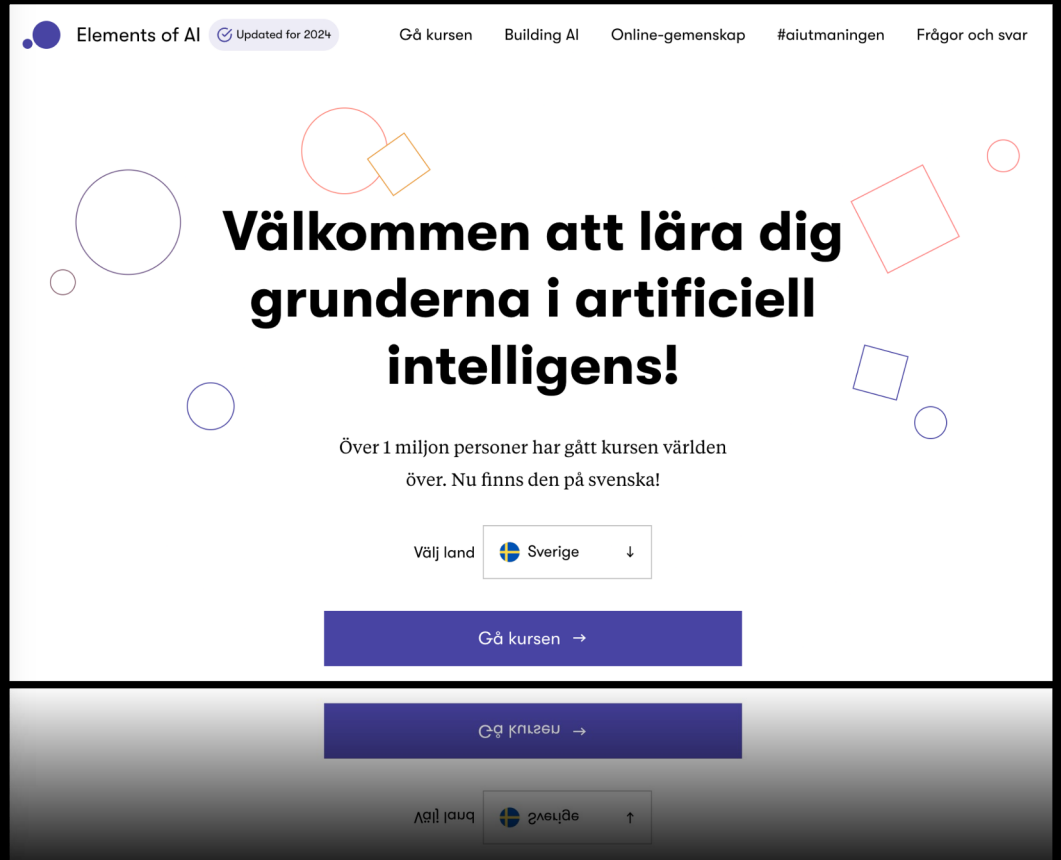
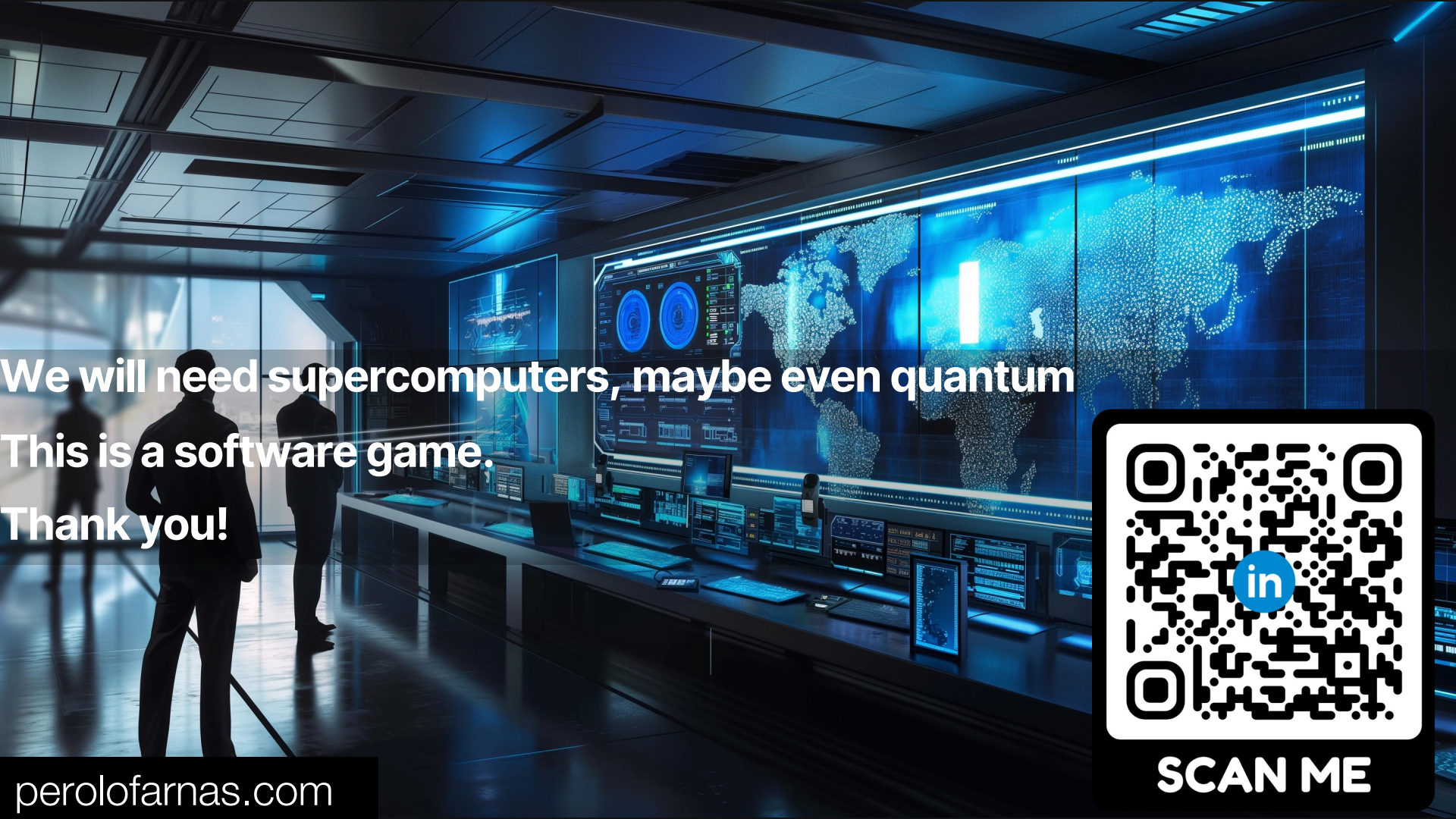
Image prompt (dialogue in ChatGPT+): How would you illustrate the concept “unknown unknowns”?

Elements of AI




We will need supercomputers, maybe even quantum
This is a software game.
Thank you!
SCAN ME
perolofarnas.com