

# *(Gen)AI for Official Statistics*

Marko Grobelnik

([Marko.Grobelnik@ijs.si](mailto:Marko.Grobelnik@ijs.si))

Artificial Intelligence Department, Jozef Stefan Institute

UNESCO IRCAI



United Nations  
Educational, Scientific and  
Cultural Organization



International Research Centre  
on Artificial Intelligence  
under the auspices of UNESCO

# Outline

- What GenAI brought to the “*Official Statistics*” table?
- Is more traditional AI still relevant?
- AI endangering human rights
- What kind of AI seems to be coming in the near future?
- How AI Innovations propagate?
- Some insights into the Geopolitics of AI







# What happened in AI after 2010?

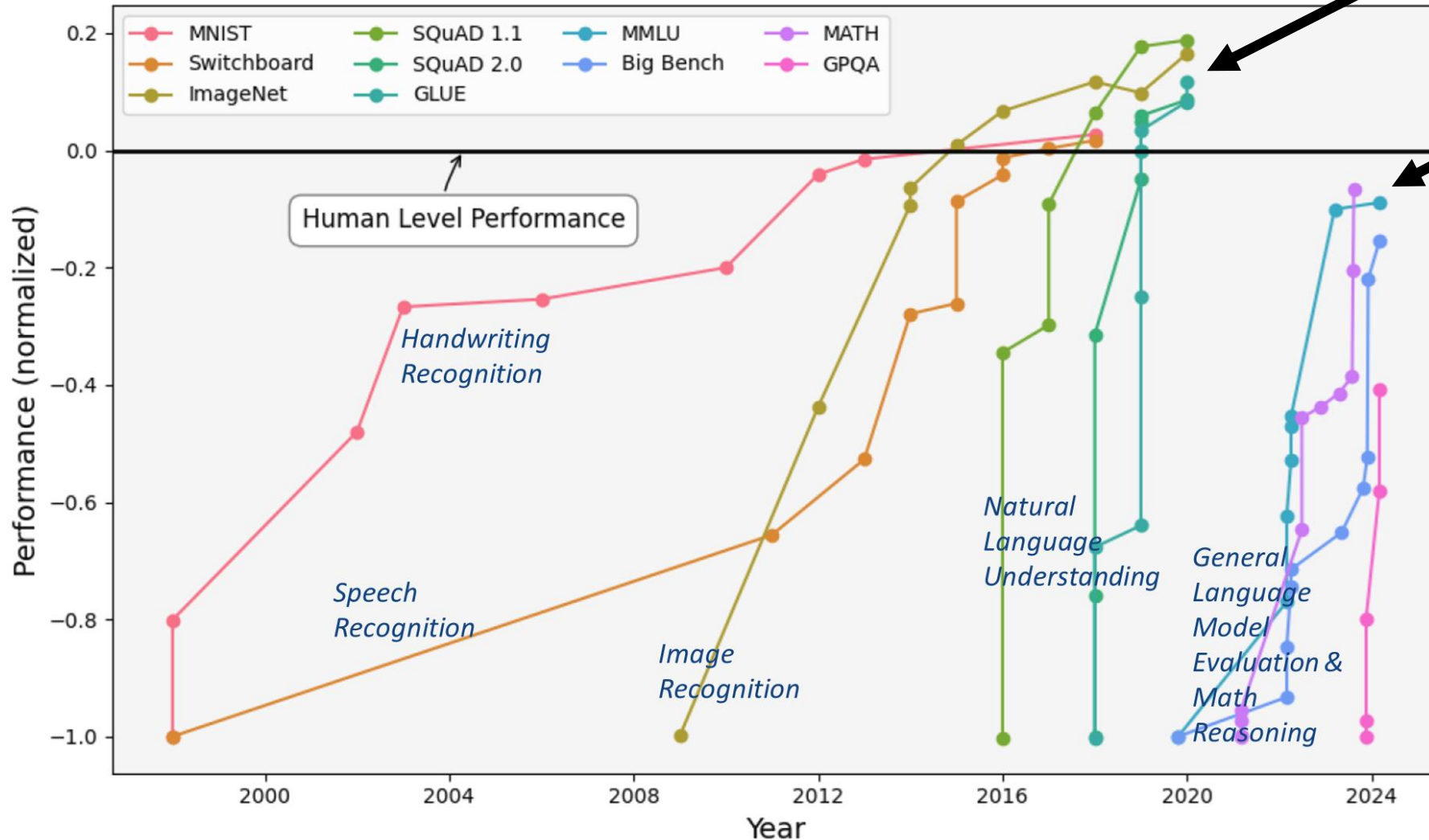
...why AI grew so fast and where it goes?

# AI Systems vs. Human Capabilities

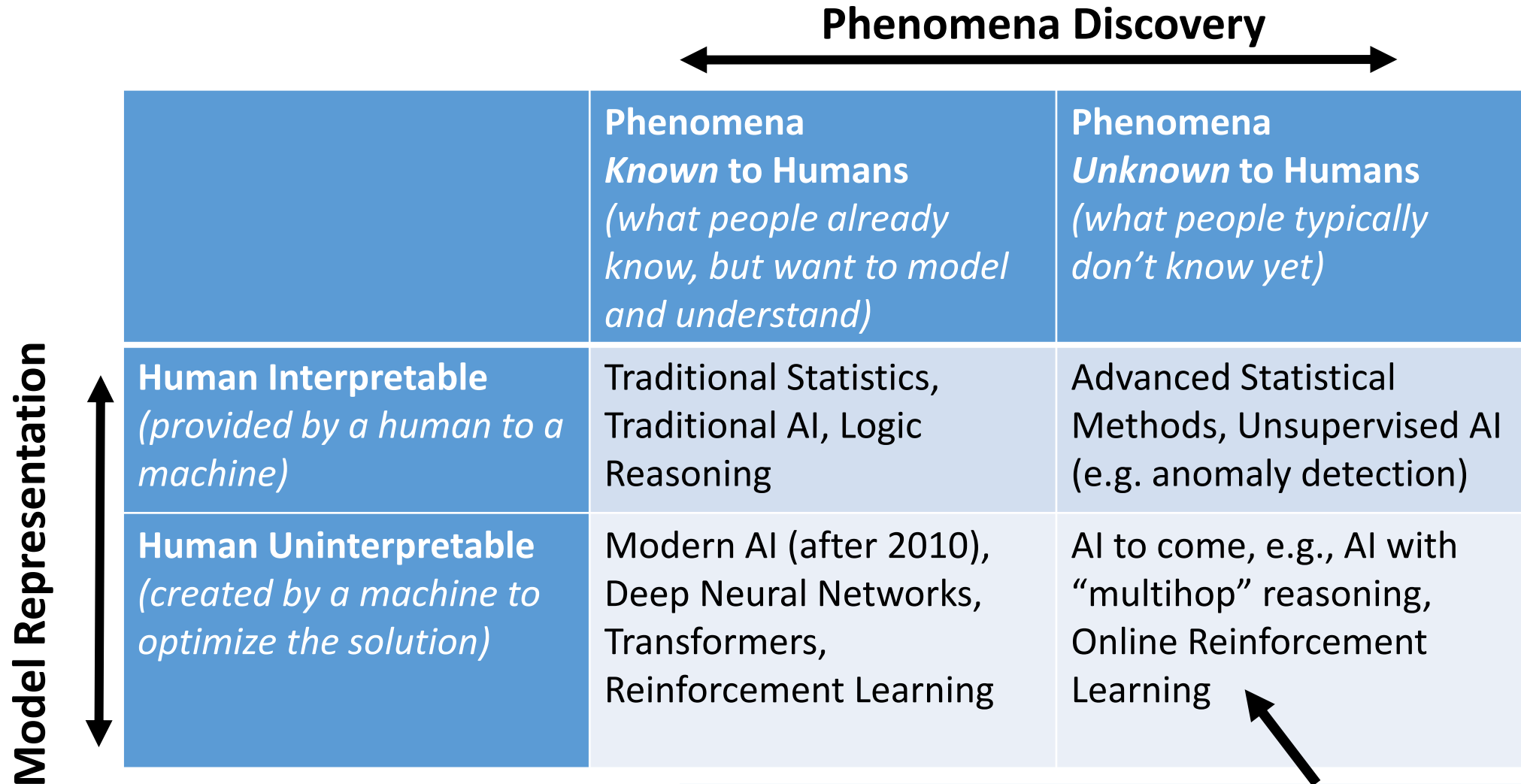
(Evolution of AI systems related to human skills)

Where we are  
(basic human skills)

Where we go  
(advanced human skills)



# (Un)Known-(Un)Knowns – Model Representation vs. Phenomena Discovery



...this would allow to reach yet undiscovered concepts and relations and reach insights far from what humanity knows today





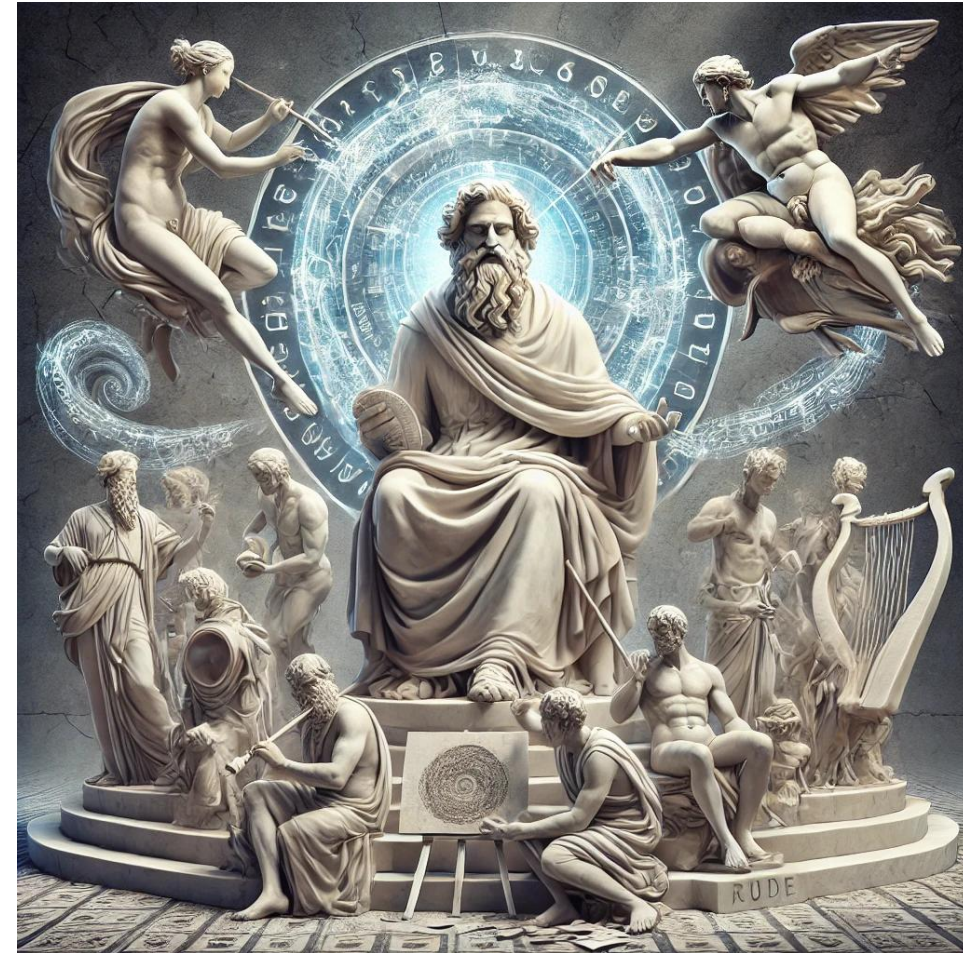
What GenAI brought to the “*Official Statistics*” table?

...good and bad sides



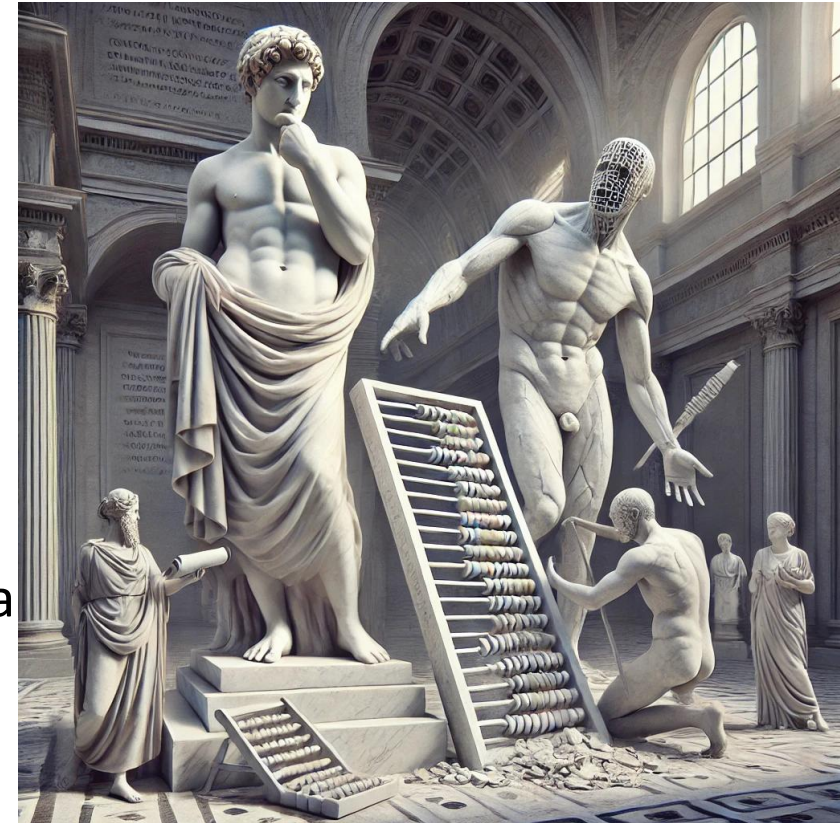
# What GenAI brought to the table for Official Statistics?

- **Extracting structure from unstructured data**
  - ...multiple data modalities: text, audio, images, video
  - ...providing causality gives (sometimes) impressive results
- **Semantic Interoperability**
  - ...aligning data schemas
  - ...contextual disambiguation and aggregation
- **Coding made easy**
  - ...generating code in programming languages (PL) from scratch
  - ...translating code from one PL to another
- **Generation of synthetic data**
  - ...strong, but used with caution
- **Uncontrolled uncertainty**
  - ...possible hallucinations at every step
  - ...sampling and other techniques can help



# Where GenAI/LLMs are not good?

- **Do not use GenAI/LLMs to deal with numbers**
  - ...e.g., do not use GenAI as a calculator
- **LLMs are good in suggesting how to structure a solution**
  - ...but cannot provide solutions themselves
  - ...e.g., good in generating code, but cannot execute the code
- **LLMs are not (yet) good in reasoning of various kinds**
  - ...i.e., whatever hasn't been seen yet, LLMs cannot invent
  - ...but are good in reproducing what has been seen in training data
  - Lots of investments recently are put in “LLM based reasoning”
- **Whenever we need scale (e.g., big data), GenAI can become expensive**
- **LLMs are not good where theoretical guarantees are needed**





# One slide summary of LLMs & Official Statistics

<i>Limitations of LLMs</i>	<i>Comments</i>	<i>Requirements of Official Statistics</i>	<i>Comments</i>
<b>Hallucinations</b>	LLMs can generate incorrect or fabricated information that appears plausible, leading to the spread of misinformation	<b>Accuracy and Reliability</b>	Official statistics must be accurate, reliable, and based on sound methodologies
<b>Limited Reasoning Skills</b>	LLMs may struggle with complex reasoning, logical deductions, and multi-step problem-solving	<b>Relevance and Timeliness</b>	The data should be relevant to user needs and provided in a timely manner
<b>Limited Knowledge</b>	LLMs are trained on static datasets and cannot update their knowledge in real-time	<b>Transparency and Impartiality</b>	The production process and methodologies should be transparent and free from bias
<b>Bias</b>	LLMs can inherit and amplify biases present in their training data, leading to discriminatory or unfair outputs	<b>Explainability</b>	The models should incorporate mechanisms to provide insights into their decision-making processes
<b>Lack of Transparency</b>	LLMs operate as "black boxes," making it difficult to understand the reasoning behind their outputs	<b>Accessibility</b>	Official statistics should be easily accessible to all users
<b>Computational Constraints</b>	LLMs require significant computational resources to operate, which can limit their scalability	<b>Confidentiality</b>	Individual data must be kept confidential and used exclusively for statistical purposes
<b>Inconsistency</b>	LLMs can generate different outputs for similar prompts or even contradict themselves within the same response .		
<b>Prompt Hacking</b>	LLMs are vulnerable to manipulation through prompt hacking, where carefully crafted prompts can be used to influence the model's output or generate misleading results		
<b>Confidentiality</b>	LLMs memorize and reproduce sensitive data from their training sets, potentially violating confidentiality		

Some Examples



# Example Schema Matching

## English Census Schema

Column Name	Data Type	Description
Census_ID	BIGINT	Unique identifier for each census record
Household_ID	BIGINT	Identifier linking individuals to a household
Person_ID	BIGINT	Unique identifier for each individual
First_Name	VARCHAR(50)	First name of the individual
Last_Name	VARCHAR(50)	Last name of the individual
Age	INT	Age of the individual
Gender	VARCHAR(10)	Gender of the individual
Marital_Status	VARCHAR(20)	Marital status of the individual
Nationality	VARCHAR(50)	Nationality of the individual
Ethnicity	VARCHAR(50)	Self-reported ethnicity of the individual
Language_Spoken	VARCHAR(50)	Primary language spoken at home
Employment_Status	VARCHAR(50)	Employment status of the individual
Occupation	VARCHAR(100)	Job title of the individual
Education_Level	VARCHAR(50)	Highest level of education completed
Household_Size	INT	Number of individuals in the household
Housing_Type	VARCHAR(50)	Type of housing (e.g., Apartment, House)
Income_Bracket	VARCHAR(50)	Income category of the individual
Region	VARCHAR(50)	Administrative region of residence
Urban_Rural	VARCHAR(10)	Classification of the area (Urban/Rural)
Disability_Status	BOOLEAN	Whether the individual has a disability
Migration_Status	VARCHAR(50)	Migration history (e.g., Native Born, Migrant)
Date_Recorded	DATE	Date when the data was recorded

## Polish Census Schema

Nazwa kolumny	Typ danych	Opis
ID_Spisu	BIGINT (PK)	Unikalny identyfikator rekordu spisu
ID_Gospodarstwa	BIGINT	Identyfikator gospodarstwa domowego
ID_Osoby	BIGINT	Identyfikator osoby
Imię	VARCHAR(50)	Imię osoby (zwrócić uwagę na prywatność)
Nazwisko	VARCHAR(50)	Nazwisko osoby (zwrócić uwagę na prywatność)
Wiek	INT	Wiek osoby
Płeć	VARCHAR(10)	Płeć (np. Mężczyzna, Kobieta, Inna)
Stan_Cywilny	VARCHAR(20)	Stan cywilny (np. Kawaler/Panna, Żonaty/Zamężna, Rozwiedziony/a, Owdowiały/a)
Obywatelstwo	VARCHAR(50)	Obywatelstwo osoby
Grupa_Etniczna	VARCHAR(50)	Samoidentyfikowana grupa etniczna
Język_Domowy	VARCHAR(50)	Główny język używany w domu
Status_Zatrudnienia	VARCHAR(50)	Status zawodowy (np. Zatrudniony/a, Bezrobotny/a, Emeryt, Student)
Zawód	VARCHAR(100)	Zawód, jeśli osoba jest zatrudniona
Poziom_Wykształcenia	VARCHAR(50)	Najwyższy ukończony poziom edukacji
Liczba_Domowników	INT	Liczba osób w gospodarstwie domowym
Typ_Zamieszkania	VARCHAR(50)	Rodzaj mieszkania (np. Blok, Dom jednorodzinny, Mieszkanie socjalne)
Przedział_Dochodowy	VARCHAR(50)	Kategoria dochodowa (np. Niski, Średni, Wysoki)
Województwo	VARCHAR(50)	Region administracyjny zamieszkania
Obszar	VARCHAR(10)	Typ obszaru (Miejski/Wiejski)
Niepełnosprawność	BOOLEAN	Czy osoba ma niepełnosprawność? (Tak/Nie)
Status_Migracyjny	VARCHAR(50)	Historia migracyjna (np. Autochton, Migrant wewnętrzny, Migrant zagraniczny)
Data_Obserwacji	DATE	Data zarejestrowania danych

English Schema (Census_Population)	Polish Schema (Spis_Ludności)	Description
Census_ID	ID_Spisu	Unique identifier for each census record
Household_ID	ID_Gospodarstwa	Identifier linking individuals to a household

## Mapping between Schemas

English Schema (Census_Population)	Polish Schema (Spis_Ludności)	Description
Person_ID	ID_Osoby	Unique identifier for each individual
First_Name	Imię	First name of the individual
Last_Name	Nazwisko	Last name of the individual
Age	Wiek	Age of the individual
Gender	Płeć	Gender of the person
Marital_Status	Stan_Cywilny	Marital status
Nationality	Obywatelstwo	Nationality
Ethnicity	Grupa_Etniczna	Self-reported ethnicity
Language_Spoken	Język_Domowy	Primary language spoken at home
Employment_Status	Status_Zatrudnienia	Employment status
Occupation	Zawód	Job title if employed
Education_Level	Poziom_Wykształcenia	Highest level of education completed
Household_Size	Liczba_Domowników	Number of individuals in the household
Housing_Type	Typ_Zamieszkania	Type of housing
Income_Bracket	Przedział_Dochodowy	Income category
Region	Województwo	Administrative region of residence
Urban_Rural	Obszar	Classification of the area (Urban/Rural)
Disability_Status	Niepełnosprawność	Whether the person has a disability
Migration_Status	Status_Migracyjny	Migration history
Date_Recorded	Data_Obserwacji	Date when the data was recorded

Here is a table of nonmatching fields between the two schemas:

Field in Census_Population (English Schema)	Field in Spis_Ludności (Polish Schema)	Reason for Non-Matching
Household_Size	(No exact match)	The Polish schema has Liczba_Domowników, but it may not be explicitly linked to Household_ID.
Region	Województwo (partial)	Województwo covers administrative regions, but Region in the English schema might include finer subdivisions (e.g., counties).
(No exact match)	Obszar	The English schema uses Urban_Rural, but Obszar may provide more specific classifications (e.g., semi-urban).

## Differences between Schemas

structured identically.

# Exceptional performance

## Financial highlights

Net income (billion)	EBIT <sup>1</sup> (billion)	Free cash flow <sup>2</sup> (billion)	Net cash provided by operating activities (billion)
SAR 604	SAR 1,149	SAR 557	SAR 698
\$161	\$307	\$149	\$186
2021: \$110	2021: \$208	2021: \$107	2021: \$139
Capital expenditures (billion)	Dividends paid (billion)	Dividends paid per share	ROACE <sup>3</sup> (%)
SAR 141	SAR 281	SAR 1.31	31.6
\$38	\$75	\$0.35	2021: 24.4
2021: \$32	2021: \$75	2021: \$0.37	
Gearing <sup>4</sup> (%)	Earnings per share (basic and diluted)	Average realized crude oil price (\$/barrel)	
(7.9)	SAR 2.72	100.2	
2021: 12.0 <sup>1</sup>	\$0.72	2021: 70.5	
	2021: \$0.48 <sup>2</sup>		

▲ 'Ain Dar gas-oil separation plant-1, Saudi Arabia

1. Gearing ratio has been amended to reflect Aramco's revised gearing definition.

2. Earnings per share have been adjusted to reflect the effect of the bonus shares issuance.

\* Non-IFRS measures refer to "Non-IFRS measures reconciliations and definitions" for further details.

Automatic  
Information  
Extraction  
from  
Infographics

### 1. Net income:

- 2022: SAR 604 billion
- 2021: \$161 billion

### 2. EBIT (Earnings Before Interest and Taxes):

- 2022: SAR 1,149 billion
- 2021: \$307 billion

### 3. Free cash flow:

- 2022: SAR 557 billion
- 2021: \$149 billion

### 4. Net cash provided by operating activities:

- 2022: SAR 698 billion
- 2021: \$186 billion

### 5. Capital expenditures:

- 2022: SAR 141 billion
- 2021: \$38 billion

### 6. Dividends paid:

- 2022: SAR 281 billion

### 7. Dividends paid per share:

- 2022: SAR 1.31
- 2021: \$0.35

### 8. ROACE (Return on Average Capital Employed):

- 2022: 31.6%
- 2021: 24.4%

### 9. Gearing (a measure of financial leverage):

- 2022: (7.9)%
- 2021: 12.0%

### 10. Earnings per share (basic and diluted):

- 2022: SAR 2.72
- 2021: \$0.72

### 11. Average realized crude oil price:

- 2022: \$100.2/barrel
- 2021: \$70.5/barrel



# Text to Knowledge Graphs using Ontologies

Text2KGBench: A Benchmark for Ontology-Driven Knowledge Graph Generation from Text

<https://arxiv.org/abs/2308.02357>

# *Prompt to initialize GPT4 with the ontology:*

## ***Prompt:***

Given the following ontology, examples and sentences, please extract the triples from the sentence according to the relations in the ontology. In the output, only include the triples in the given output format.

## **CONTEXT:**

**Ontology Concepts:** human, city, country, film, film genre, film production company, film award, award, written work, film character, film organization

**Ontology Relations:** cast\_member(film, human), director (film, human), screenwriter (film, human), producer(film, human), genre(film, genre), based\_on(film, written work), award\_received (film,award), production\_company(film, film production company), country\_of\_origin(film, country), publication\_date (film,date), characters(film, film character), narrative\_location (film,city), filming\_location (film, city), main\_subject(film, thing), nominated\_for(film, award), cost(film, number)



# Prompt to extract KG from English Oppenheimer movie description:

[https://en.wikipedia.org/wiki/Oppenheimer\\_\(film\)](https://en.wikipedia.org/wiki/Oppenheimer_(film))

Test Sentence: Oppenheimer is a 2023 epic biographical drama film[5] written and directed by Christopher Nolan and starring Cillian Murphy as J. Robert Oppenheimer, the American theoretical physicist credited with being the "father of the atomic bomb" for his role in the Manhattan Project—the World War II undertaking that developed the first nuclear weapons. The film is based on the 2005 biography American Prometheus by Kai Bird and Martin J. Sherwin, it chronicles the career of Oppenheimer; the story predominantly focuses on Oppenheimer's studies, his direction of the Manhattan Project during World War II, and his eventual fall from grace due to his 1954 security hearing. In addition to Murphy, the film stars Emily Blunt as his wife "Kitty", Matt Damon as head of the Manhattan Project Leslie Groves, Robert Downey Jr. as U.S. Atomic Energy Commission member Lewis Strauss, and Florence Pugh as Oppenheimer's communist lover Jean Tatlock. The ensemble supporting cast includes Josh Hartnett, Casey Affleck, Rami Malek, and Kenneth Branagh. The film was announced in September 2021 after Universal Pictures won a bidding war for Nolan's screenplay, following Nolan's conflict with longtime distributor Warner Bros. Murphy was the first cast member to sign on the following month, with the rest of the cast joining between November 2021 and April 2022. Pre-production was under way by January 2022, and filming took place from February to May. Oppenheimer was filmed in a combination of IMAX 65 mm and 65 mm large-format film, including, for the first time, select scenes in IMAX black-and-white film photography. Like his previous works, Nolan made extensive use of practical effects, with minimal computer-generated imagery merely to perfect the former. Editing was handled by Jennifer Lame, and the score was composed by Ludwig Göransson. The film is Nolan's third to receive an R-rating in the United States, the first being Memento (2000) and the second being Insomnia (2002). Oppenheimer premiered at Le Grand Rex in Paris on July 11, 2023, and was theatrically released in the United States and United Kingdom on July 21 by Universal. Its simultaneous release with Warner Bros.'s Barbie led to the Barbenheimer cultural phenomenon, which encouraged audiences to see both films as a double feature. The film grossed \$903 million worldwide on a \$100 million production budget, becoming the third-highest-grossing film of 2023, the highest-grossing World War II-related film of all time,[6] the highest-grossing biographical film of all time,[7] and the second-highest-grossing R-rated film of all time.[8] It received critical acclaim, with particular praise for the cast performances, screenplay, and visuals.



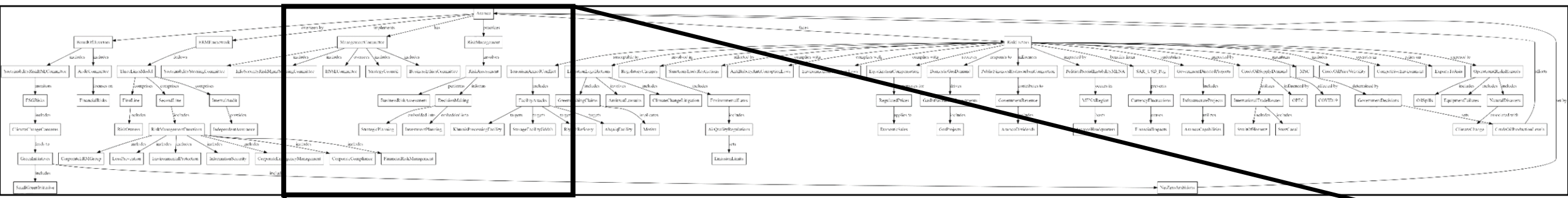
GPT4

**director(Oppenheimer, Christopher Nolan)**  
**screenwriter(Oppenheimer, Christopher Nolan)**  
**cast\_member(Oppenheimer, Cillian Murphy)**  
**cast\_member(Oppenheimer, Emily Blunt)**  
**cast\_member(Oppenheimer, Matt Damon)**  
**cast\_member(Oppenheimer, Robert Downey Jr.)**  
**cast\_member(Oppenheimer, Florence Pugh)**  
**cast\_member(Oppenheimer, Josh Hartnett)**  
**cast\_member(Oppenheimer, Casey Affleck)**  
**cast\_member(Oppenheimer, Rami Malek)**  
**cast\_member(Oppenheimer, Kenneth Branagh)**  
**based\_on(Oppenheimer, American Prometheus)**  
**production\_company(Oppenheimer, Universal Pictures)**  
**production\_company(Oppenheimer, Warner Bros.)**  
**publication\_date(Oppenheimer, 2023)**  
**narrative\_location(Oppenheimer, United States)**  
**narrative\_location(Oppenheimer, United Kingdom)**  
**narrative\_location(Oppenheimer, Paris)**  
**filming\_location(Oppenheimer, Le Grand Rex)**  
**cost(Oppenheimer, 100 million)**  
**award\_received(Oppenheimer, third-highest-grossing film of 2023)**  
**award\_received(Oppenheimer, highest-grossing World War II-related film of all time)**  
**award\_received(Oppenheimer, highest-grossing biographical film of all time)**  
**award\_received(Oppenheimer, second-highest-grossing R-rated film of all time)**  
**genre(Oppenheimer, epic biographical drama film)**

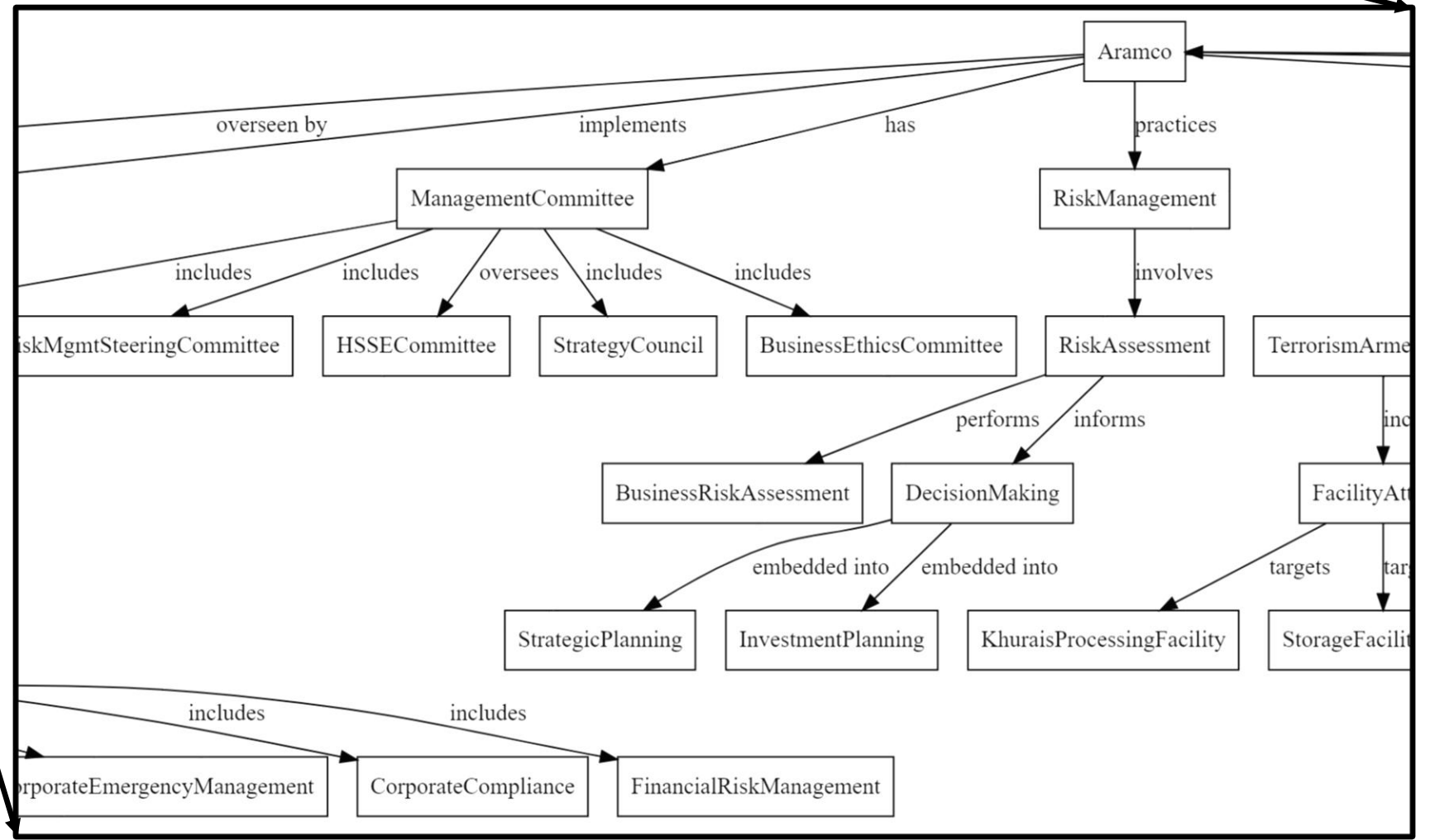
# More Knowledge Graphs

## Examples



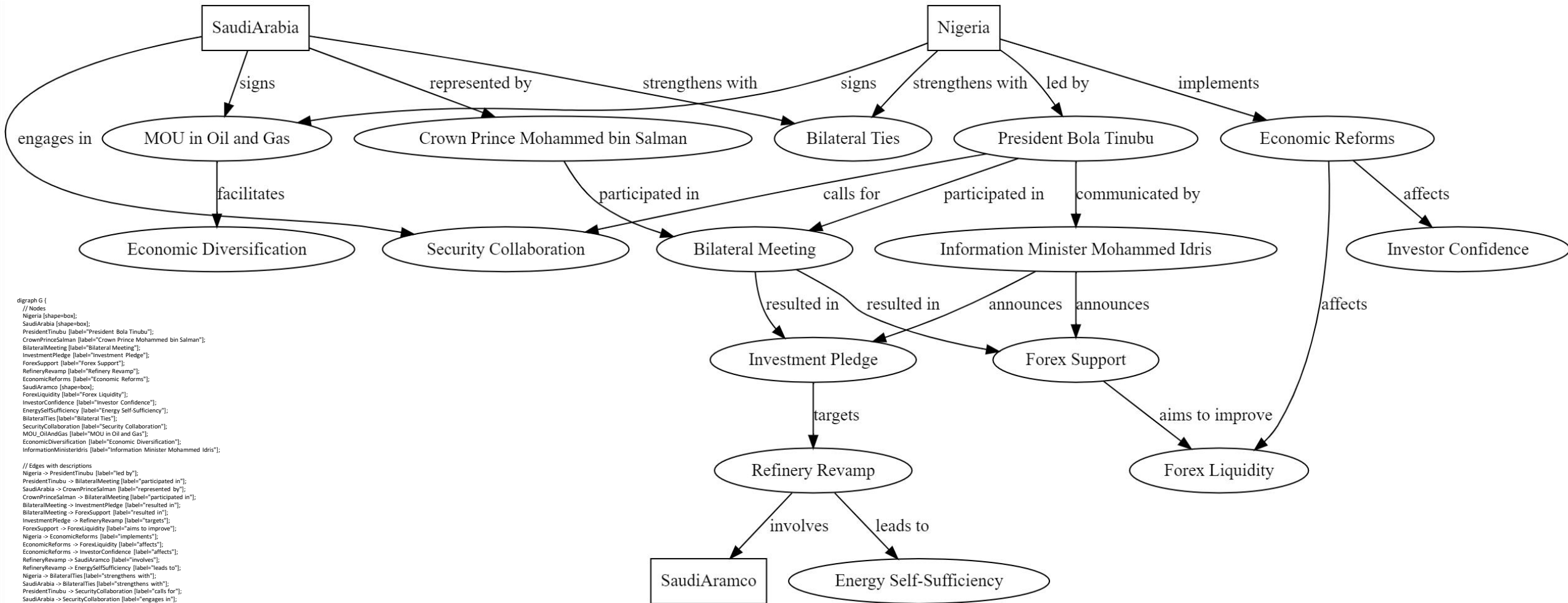


Knowledge Graph  
 Extracted from  
 the complete  
 Risk Management  
 Section of the  
 Annual Report 2022  
 (~100 pages)



# Knowledge Graph extracted from the article

<https://www.reuters.com/world/africa/nigeria-gets-refineries-investment-forex-pledge-saudi-arabia-2023-11-10/>



```

digraph G {
  // Nodes
  Nigeria [shape=box];
  SaudiArabia [shape=box];
  PresidentTinubu [label="President Bola Tinubu"];
  CrownPrinceSalman [label="Crown Prince Mohammed bin Salman"];
  BilateralMeeting [label="Bilateral Meeting"];
  InvestmentPledge [label="Investment Pledge"];
  ForexSupport [label="Forex Support"];
  RefineryRevamp [label="Refinery Revamp"];
  EconomicReforms [label="Economic Reforms"];
  SaudiAramco [shape=box];
  ForexLiquidity [label="Forex Liquidity"];
  InvestorConfidence [label="Investor Confidence"];
  EnergySelfSufficiency [label="Energy Self-Sufficiency"];
  BilateralTies [label="Bilateral Ties"];
  SecurityCollaboration [label="Security Collaboration"];
  MOU_OilAndGas [label="MOU in Oil and Gas"];
  EconomicDiversification [label="Economic Diversification"];
  InformationMinisterIdris [label="Information Minister Mohammed Idris"];

  // Edges with descriptions
  Nigeria -->|led by| PresidentTinubu;
  PresidentTinubu -->|participated in| BilateralMeeting;
  SaudiArabia -->|represented by| CrownPrinceSalman;
  CrownPrinceSalman -->|participated in| BilateralMeeting;
  BilateralMeeting -->|resulted in| InvestmentPledge;
  BilateralMeeting -->|resulted in| ForexSupport;
  BilateralMeeting -->|results in| ForexLiquidity;
  BilateralMeeting -->|results in| EnergySelfSufficiency;
  BilateralMeeting -->|results in| InvestorConfidence;
  InvestmentPledge -->|targets| RefineryRevamp;
  RefineryRevamp -->|involves| SaudiAramco;
  RefineryRevamp -->|leads to| EnergySelfSufficiency;
  EconomicReforms -->|affects| InvestorConfidence;
  EconomicReforms -->|affects| ForexLiquidity;
  SaudiArabia -->|signs| MOU_OilAndGas;
  SaudiArabia -->|engages in| EconomicDiversification;
  SaudiArabia -->|facilitates| EconomicDiversification;
  SaudiArabia -->|facilitates| SecurityCollaboration;
  SaudiArabia -->|facilitates| BilateralMeeting;
  SaudiArabia -->|facilitates| InvestmentPledge;
  SaudiArabia -->|facilitates| ForexSupport;
  SaudiArabia -->|facilitates| ForexLiquidity;
  SaudiArabia -->|facilitates| EnergySelfSufficiency;
  SaudiArabia -->|facilitates| InvestorConfidence;
  Nigeria -->|signs| BilateralTies;
  Nigeria -->|strengthens with| BilateralTies;
  Nigeria -->|led by| PresidentTinubu;
  Nigeria -->|implements| EconomicReforms;
  Nigeria -->|affects| InvestorConfidence;
  CrownPrinceSalman -->|participated in| BilateralMeeting;
  CrownPrinceSalman -->|calls for| SecurityCollaboration;
  CrownPrinceSalman -->|calls for| InvestmentPledge;
  CrownPrinceSalman -->|calls for| ForexSupport;
  CrownPrinceSalman -->|calls for| ForexLiquidity;
  CrownPrinceSalman -->|calls for| EnergySelfSufficiency;
  CrownPrinceSalman -->|calls for| InvestorConfidence;
  PresidentTinubu -->|participated in| BilateralMeeting;
  PresidentTinubu -->|participated in| ForexSupport;
  PresidentTinubu -->|communicated by| InformationMinisterIdris;
  PresidentTinubu -->|affects| InvestorConfidence;
  InformationMinisterIdris -->|announces| InvestmentPledge;
  InformationMinisterIdris -->|announces| ForexSupport;
}
  
```

# Article One

<https://www.legit.ng/business-economy/energy/1563097-saudi-arabias-aramco-fix-nigerias-refineries-supply-cbn-foreign-exchange/>

Saudi Arabia pledges FX support for CBN and refinery overhaul in Nigeria ADEKUNLE AGBETILOYE November 11, 2023 4:00 AM President Tinubu and the Kingdom's leader, Crown Prince, HRH Mohammed Bin Salman. President Tinubu and the Kingdom's leader, Crown Prince, HRH Mohammed Bin Salman. The Saudi Arabian government has pledged its support for the ongoing reforms initiated by the Central Bank of Nigeria. It also committed to rejuvenating the country's existing refineries in collaboration with its state-owned oil company, Aramco. Additionally, the Crown Prince of Saudi Arabia has pledged support to Nigeria in agriculture, renewable energy, and the oil industry. The Saudi Arabian government has pledged its support for the ongoing reforms initiated by the Central Bank of Nigeria, and also committed to rejuvenating the country's existing refineries in collaboration with its state-owned oil company, Aramco. ADVERTISEMENT RECOMMENDED ARTICLES Elon Musk and a Starlink set. Markets Nigeria in talks with Elon Musk's Starlink to create jobs in Nigeria Growth obstacles to family businesses in East Africa may be self-inflicted Markets Growth obstacles to family businesses in East Africa may be self-inflicted South Africa Markets South Africa plans to utilize \$12.5 billion loans to tackle grid overload This commitment was reached at a bilateral meeting between Nigerian President Bola Tinubu and Saudi Crown Prince Mohammed bin Salman on the sidelines of the Saudi-Africa summit in Riyadh. This was revealed in a statement signed by the Minister of Information and National Orientation, Muhammed Idris. "To support the Central Bank's ongoing reforms of Nigeria's foreign exchange regime, the Saudi Government will make available a substantial deposit of foreign exchange to boost Nigeria's forex liquidity," the statement read. ADVERTISEMENT In addition, the Saudi government, via Saudi Aramco, will make investments in the renovation of Nigeria's four ailing state-owned refineries, with the anticipated completion of the project within two to three years. Saudi Crown Prince Mohammed Bin Salman praised President Tinubu's economic reforms, expressing Saudi Arabia's commitment to supporting these efforts for Nigeria's full benefit. Under President Tinubu's leadership, Nigeria has implemented several economic reforms, including the removal of a popular petrol subsidy and the streamlining of the country's multiple exchange rates. Salman stressed Saudi Arabia's eagerness to witness Nigeria's success under President Bola Tinubu and its realization of its full potential as the economic giant of Africa. Additionally, the Crown Prince of Saudi Arabia has pledged support to Nigeria in agriculture, renewable energy, and the oil industry. Plans include the revitalization of Nigeria's refinery within a three-year timeframe.



# Article Two

<https://africa.businessinsider.com/local/markets/saudi-arabia-pledges-fx-support-for-cbn-and-refinery-overhaul-in-nigeria/yww3zlv>

Saudi Arabia's Aramco to Help Fix Nigeria's Refineries, Supply CBN With Forex to Strengthen Naira Updated Saturday, November 11, 2023 at 9:05 AM by Pascal Oparada The Kingdom of Saudi Arabia has promised to help Nigeria's CBN with the current foreign exchange scarcity The Kingdom's Crown Prince Mohammed Bin Salman pledged during a visit by President Tinubu The country also promised to help fix Nigeria's refineries via its Saudi Aramco, the world's most prominent oil firm PAY ATTENTION: Unlock the best of Legit.ng on Pinterest! Subscribe now and get your daily inspiration! Pascal Oparada has over a decade of experience covering Tech, Energy, Stocks, Investments, and Economy. The government of Saudi Arabia has promised to support the reforms of the Central Bank of Nigeria and help fix Nigeria's refineries through its oil company, Aramco. The country pledged a bilateral engagement between President Bola Tinubu and Crown Prince Mohammed Bin Salman. Governor of the Central Bank of Nigeria, Olayemi Cardoso, and Saudi Arabia's Crown Prince, Mohammed Bin Salman Credit: FAYEZ NURELDINE / Contributor Source: Getty Images Saudi Arabia promises to help Nigeria with Forex liquidity and fix Nigeria's refineries The Minister of Information and National Orientation, Mohammed Idris, disclosed this in a press statement. READ ALSO FG replies to Peter Obi's criticism over supplementary budget PAY ATTENTION: Share your outstanding story with our editors! Please reach us through info@corp.legit.ng! The statement said that the Saudi Prince commended the reforms of the current CBN management and promised to support Nigeria in other areas. Per the statement, the Kingdom will support the CBN's FX reforms and help make available enough forex exchange to fix Nigeria's forex scarcity. Idris said that Prince Bin Salman commended the economic policies of President Tinubu and expressed the commitment of the Saudi government to supporting the reforms and helping Nigeria to benefit from the reforms. "Saudi Arabia is very eager to see Nigeria thrive under President Bola Tinubu and realize its full potential as the economic giant of Africa," the statement said. Reports say the Kingdom also promised to support Nigeria in agriculture, renewable energy, and the oil industry with plans to revamp Nigeria's refineries in three years. The two leaders committed to fashioning out a roadmap to develop discussed during the meeting. READ ALSO NNPC explains why India abandons Nigeria's crude oil for Russia's Saudi Arabia owns the world's most profitable oil company Saudi Arabia is the world's leading oil producer and has one of the most profitable state-owned oil firms, Saudi Aramco. Saudi Aramco is said to have the most significant bid in the world, the Wall Street Journal report said. Officials of the oil firm said it planned to sell about \$50 billion worth of shares, which will be the largest in the world if successfully executed. The country decided to hold any fresh Aramco offering on the Riyadh stock exchange to avoid regulatory concerns arising with international listings. Saudi Aramco is the world's largest oil firm, with a market value of \$2.25 trillion, with its shares up 20% in 2023. Saudi Aramco plans the world's most extensive share listing Reports say the company could hold the offer before the end of 2023 despite a final decision still being awaited. READ ALSO FG, NESG, other stakeholders synergise to improve Nigeria's food safety standards The oil firm has attempted stock listing, with the Kingdom's Crown Prince Bin Salman staking his reputation on Aramco's vast IPO some years ago. The IPO includes a possible sale of New York Stock Exchange shares, but doubts about valuation and the risks concerning the 9/11 attacks delayed the offering. The move stopped the national oil company from pursuing the most extensive offer. It chose to list in Tadawul only on December 11, 2019, when 1.5% of its value began trading on the stock markets. According to available data, Saudi Arabia has some of the world's most robust forex reserves, with \$402 billion as of August 2023. Nigeria struggles with a paltry less than \$32 billion in reserves. "No be the same oil we dey Sell?" Nigerians ask as Saudi Arabia adds \$80BN oil money to its wealth fund Legit.ng reported that while the Nigerian National Petroleum Company Limited (NNPCL) struggles to remit money to the federation accounts, Saudi Arabia's Aramco has added \$80 billion worth of shares into the country's sovereign wealth fund. READ ALSO Jubilation as President Tinubu makes fresh appointment A sovereign wealth fund (SWF), also known as a social wealth fund, is the surplus money that a country accrues over time. According to a statement released by the official Saudi Press Agency, the shares were transferred to Sanabil Investments, a firm controlled by the kingdom's Public Investment Fund (PIF).

Aspect	Article One	Article Two
<b>Focus on Collaboration</b>	Emphasizes Saudi Arabia's support for Nigeria's economic reforms and the renovation of state-owned refineries.	Highlights Saudi Aramco's specific role in fixing Nigeria's refineries and aiding with Forex scarcity.
<b>Details on Economic Support</b>	Mentions broader economic support, including agriculture and renewable energy.	Specifically focuses on Forex liquidity support and the refurbishing of refineries.
<b>Scope of Saudi Involvement</b>	Broader, including multiple sectors like agriculture, energy, and oil.	More focused on the oil industry and financial support.
<b>Completion Timeframe for Projects</b>	Refers to a general timeframe for the completion of refinery renovations.	Does not specify a timeframe for the completion of refinery renovations.
<b>Emphasis on Saudi Leadership</b>	The role of Crown Prince Mohammed Bin Salman is mentioned but not deeply elaborated.	Highlights the personal commitment and involvement of Crown Prince Mohammed Bin Salman in the initiatives.
<b>Detailing of Nigeria's Reforms</b>	Provides context about President Tinubu's leadership and economic reforms in Nigeria.	More focus on the Saudi Arabian perspective and support, with less detail on Nigeria's internal reforms.



27 pages

50 sentences

20 sentences

10 sentences

5 sentences

1 sentence

# Understanding risks Section from Aramco Annual Report

1. Saudi Aramco acknowledges a multitude of operational and strategic risks that may not be immediately apparent but could become material in the future.
2. The company's financial health is heavily influenced by international crude oil prices, which can fluctuate widely due to market dynamics.
3. Aramco's revenue is highly dependent on crude oil sales, making it vulnerable to shifts in global supply and demand.
4. External factors like economic conditions, geopolitical events, and trade policies significantly affect crude oil prices.
5. OPEC decisions, natural disasters, and pandemics like COVID-19 can create drastic changes in the demand and supply of oil.
6. Technological advancements in oil extraction and transportation can impact the oil market and Aramco's operations.
7. The company faces risks related to climate change, which could reduce global hydrocarbon demand and necessitate costly investments.
8. Environmental and safety regulations have become stricter, potentially leading to new operational challenges for Aramco.
9. The potential emergence of alternative energy sources could impact the crude oil market and Aramco's sales.
10. Electrification of transport and advancements in electric vehicle technology pose risks to the traditional hydrocarbon market.
11. Currency fluctuations, particularly in the value of the U.S. dollar, can influence Aramco's global pricing and revenue.
12. Aramco's operations are susceptible to risk on price volatility, as seen in historical price trends between 2016 and 2022.
13. OPEC's production cuts and geopolitical conflicts like the Russia-Ukraine crisis have contributed to price fluctuations.
14. Competition in the crude oil market is intense, with Aramco competing against other wells and international and national companies.
15. Crude oil pricing competition affects Aramco's market share and revenue from sales outside the Kingdom.
16. Refining and petrochemical plants also face competition based on operating efficiencies and production costs.
17. Climate concerns are leading to actions intending to reduce fossil fuel use, such as international agreements to lower GHG emissions.
18. To contribute to Saudi Arabia's climate goals, Aramco has set an ambition to achieve net-zero Scope 1 and Scope 2 GHG emissions by 2050.
19. Aramco's facilities are at risk from terrorism and ongoing conflict, with past attacks having disrupted operations.
20. Attacks on Aramco's critical infrastructure, like the Abqaiq facility, highlight the ongoing threat to its core assets.
21. Aramco's substantial exports to Asia link its financial performance to the region's economic and political stability.
22. Shifts in Asia's economies, adversely affected by COVID-19, could lead to decreased demand for Aramco's hydrocarbons.
23. Aramco's Downstream segment engages in international operations, which are subject to regulatory risks.
24. The company faces operational risks like spills, accidents, and natural disasters, impacting its production and incurring liabilities.
25. Risks of industrial accidents pose threats to human safety, the environment, and Aramco's financial and operational efficiency.
26. The company's network infrastructure and key processing facilities remain vulnerable to disruptive incidents or attacks.
27. The COVID-19 pandemic and potential future health crises show the susceptibility of Aramco's business to global economic turmoil.
28. Issues stemming from health emergencies can affect Aramco's workforce, operations, and product demand.
29. Estimates of Aramco's hydrocarbon reserves depend on interpretations and assumptions that, if incorrect, could impact its asset valuation.
30. The company's financial performance could suffer from deviations in the estimated quantity or value of its proved reserves.
31. Aramco's legal entity structure and insurance coverage may not fully mitigate risks from catastrophic events and liabilities.
32. Projects underpinning Aramco's strategic growth, if unsuccessful or delayed, could impact production and profitability targets.
33. Aramco's historical financial performance cannot be relied upon due to changes in the fiscal regime affecting comparability.
34. Acquisitions, such as the stake in SABIC, present risks including integration difficulties and unexpected costs or liabilities.
35. For Aramco, operating internationally involves risks related to regulations, taxation, currency fluctuations, and political developments.
36. The loss or turnover of Senior Management and key personnel could hamper the company's ability to maintain competitive performance.
37. Reliable and secure IT systems are crucial for Aramco, with cyber threats posing a risk to operations and data integrity.
38. Aramco is involved in significant litigation, including antitrust lawsuits in the U.S. linked to its participation in OPEC.
39. Lawsuits related to climate change risk could bring financial liabilities and damage Aramco's reputation and market value.
40. Trade restrictions or measures against Aramco's exports could adversely affect its business.
41. Regulatory changes within Saudi Arabia's oil and gas sector may impact Aramco's rights under the Concession agreement.
42. Compliance with sanctions and anti-bribery laws in different jurisdictions could subject Aramco to penalties or sanctions.
43. Aramco must secure and renew governmental licenses and approvals to operate, where a failure could mean penalties and operational interruptions.
44. Environmental regulations concerning products and production methods may incur costs and prompt operational changes for Aramco.
45. Changes to the government's equalization compensation mechanism for domestic sales could affect Aramco's earnings.
46. The government-mandated separation of Aramco's downstream business has tax implications and must be achieved within a specified period.
47. The Saudi government's decisions on crude oil production levels and maintenance of MSC impact Aramco's operational autonomy.
48. Aramco's financial outcomes are connected to the health of Saudi Arabia's economy, which relies significantly on oil revenues.
49. Aramco's central location in MENA exposes it to regional political and social instability, which can affect investor sentiment.
50. Any discontinuation of the SAR peg to the U.S. dollar could affect Aramco's costs and dividends, straining its financial position.

# Summarization Process

1. Saudi Aramco faces a diverse array of risks, some not currently apparent, that may later materialize to affect its operations, financial health, and market share valuations.
2. As a major oil company, Aramco's financial outcomes are closely tied to international crude oil demand and pricing, which are driven by factors such as global economic conditions and geopolitical events.
3. Aramco's revenue is primarily reliant on crude oil sales, with market susceptibility leading to potential significant impacts on cash flow and operational results from price volatility.
4. The competitive nature of the global oil market poses risks to Aramco's ability to secure oil profitably without incurring powerful international and national competitors.
5. Environmental and climate change concerns, including regulatory responses like the Paris Agreement, are influencing demand for fossil fuels and compelling Aramco towards clean energy investments.
6. Aramco's facilities have been targets of terror attacks and armed conflicts, with incidents in recent years affecting operations and underscoring the threat to its business model.
7. The Asian market, as the primary consumer of Aramco's exports, is crucial to its success; political and economic instability in Asia could lead to decreased demand and revenue.
8. Aramco is subject to various operational risks such as equipment failures, and natural disasters, each of which could cause operational disruptions and financial liabilities.
9. The COVID-19 pandemic demonstrated the potential for global diseases to negatively affect economic conditions and demand for Aramco's products, impacting business and operating results.
10. Fluctuating global capital markets and investor sentiment can affect Aramco's access to financing and its ability to execute its strategic growth objectives and maintain profitability.
11. Changes in estimates of proved hydrocarbon reserves due to inaccuracies or changing conditions could adversely affect the valuation of Aramco's reserve assets and financial position.
12. The company's significant litigation exposure, especially in the US regarding antitrust laws related to OPEC membership, could result in substantial penalties and impact business operations.
13. Aramco's operations and growth are dependent on obtaining and maintaining relevant governmental licenses, permits, and approvals, any disruption of which could adversely affect its business.
14. The potential impact of stricter environmental protection, health, and safety regulations could introduce new operational challenges and increase compliance costs for Aramco.
15. Aramco must comply with an equalization mechanism set by the Saudi government for domestic energy sales, which balances revenues lost to regulated pricing but could change unfavorably.
16. To achieve its strategic objectives, Aramco relies on the successful delivery of projects, which are at risk from market forces, funding availability, and technical challenges.
17. The company's financials are impacted by the government-mandated separation of Aramco's downstream business, a process that must be completed within a specified timeframe or face retroactive taxation.
18. Government control over Saudi Arabia's crude oil production and Maximum Sustainable Capacity (MSC) poses risks to Aramco's operational autonomy and profitability.
19. The fiscal dependency of the Saudi government on the hydrocarbon industry connects Aramco's financial performance directly to the national economy's stability and growth.
20. Lastly, given its central headquarters and operations in the MENA region, Aramco is susceptible to regional instability, which can directly influence its operational and financial outcomes.

1. Saudi Aramco faces numerous risks, some known and others that may currently be considered immaterial, which could potentially affect its financial position, operations, and share value in the future.
2. The company's financial results and cash flow are significantly dependent on the fluctuating international crude oil market, which is influenced by factors outside of Aramco's control.
3. Aramco operates in a highly competitive oil industry, with numerous international and national companies vying for market shares. The company could face a major inability to sell crude oil and other products at competitive prices.
4. Growing concerns about climate change and the regulatory responses to it could reduce the global demand for hydrocarbons, posing risks to Aramco's business model and necessitating significant investment in lower carbon intensity technologies.
5. Terrorism and regional conflicts pose material risks to Aramco's operations, evidenced by past attacks on its facilities, which could disrupt operations and adversely affect its business and share price.
6. The economic health and political stability of Asian markets are critical for Aramco, as a substantial portion of its exports are destined for that region, making it susceptible to regional downturns or policy shifts.
7. Aramco's operations are fraught with inherent industry hazards, such as spills, leaks, and disruptions from natural disasters, which could impose significant remediation costs or operational setbacks.
8. The COVID-19 pandemic's impact on global economic conditions has demonstrated the potential for infectious diseases to adversely affect the demand for Aramco's products and disrupt its operations.
9. The article also highlights the potential financial and operational implications of litigation, regulatory changes, and insurance limitations that Aramco may face.
10. Aramco's strategic growth, including plans to separate its downstream operations and achieve stated climate goals, relies on successful project delivery, which is subject to the risks of increased costs, delays, and shifting market demands.

1. Saudi Aramco is exposed to a multitude of risks including volatile oil prices, geopolitical instability, and competitive pressures that can materially impact its revenue and operations.
2. The company's reliance on crude oil sales, which are subject to global supply and demand dynamics, significantly influences its financial results and cash flows.
3. Concerns over climate change and regulatory responses may lead to reduced hydrocarbon demand and require Aramco to invest in alternative energy solutions.
4. Aramco's facilities are at risk from terrorism and conflicts in the Middle East, with previous attacks highlighting the potential for operational disruptions.
5. The COVID-19 pandemic has underscored the vulnerability of Aramco's business to public health crises, which can affect market conditions and reduce demand for oil and gas products.

The article outlines the various risks and challenges that Saudi Aramco faces, including market volatility, competition, climate change, geopolitical conflicts, and operational hazards, that could significantly impact its business operations and financial performance.

# *Anti-Summarization/Text Expansion – more text with the same meaning*

Original text

175 words

## **Global**

Despite geopolitical tensions, high inflation and sharply rising interest rates that formed strong economic headwinds, the global economy expanded by an estimated 3.1% in 2022, compared to 6.1% in 2021. Global GDP growth is expected to slow to a meager 1.5% in 2023 as these headwinds are expected to continue into 2023.<sup>1</sup>

In 2022 worldwide oil demand is estimated to have increased by 2.5 mmbpd to 99.8 mmbpd, while global oil supply is estimated to have averaged 100.8 mmbpd.<sup>2</sup> Despite this oversupplied position, the ICE Brent crude oil price averaged \$99 per barrel in 2022, approximately 39.8% higher than the average of \$71 per barrel in 2021, as market conditions in the first half of the year drove prices to a peak of \$128 per barrel.

308 words

In 2022, the global economy faced significant challenges including geopolitical tensions, high inflation, and rising interest rates, yet it expanded by an estimated 3.1%, down from 6.1% in 2021. This slowdown is attributed to the lingering effects of the COVID-19 pandemic, supply chain disruptions, and international conflicts, which have impacted global trade and investment. Despite these obstacles, certain sectors like technology and healthcare remained robust, though industries sensitive to interest rates, such as real estate, experienced more strain. Looking ahead, 2023 is expected to see a further slowdown in global growth, with projections of a mere 1.5% increase. This anticipated decline is due to persistent factors such as inflation and geopolitical instability, compounded by ongoing supply chain challenges and potential trade disruptions.

In the energy domain, 2022 witnessed a significant rise in oil demand, estimated at 2.5 million barrels per day, reaching 99.8 mmbpd. This increase was largely fueled by the economic recovery post-pandemic, as industrial and transportation activities surged. However, the global oil supply also rose, averaging 100.8 mmbpd.

Despite this apparent oversupply, the average ICE Brent crude oil price was \$99 per barrel in 2022, a 39.8% increase from \$71 in 2021. This hike in prices was influenced by production cuts, geopolitical tensions in oil-producing regions, and currency fluctuations. The first half of the year saw prices peak at \$128 per barrel, driven by high demand and concerns over supply interruptions. These fluctuations in oil prices had broad economic impacts, contributing to inflation and affecting various sectors, especially transportation and manufacturing. Conversely, oil-producing nations benefited from increased revenues, potentially aiding in economic diversification and stabilization.

Overall, 2022's economic landscape was shaped by a blend of resilience and challenges, with the energy sector, particularly oil, playing a crucial role. As 2023 unfolds, the ongoing and emerging factors will continue to influence the global economic and energy outlook.

475 words

In 2022, the global economy faced a complex mix of challenges, including geopolitical tensions, surging inflation, and sharply rising interest rates, yet managed to expand by an estimated 3.1%, a noticeable decline from the 6.1% growth seen in 2021. This slowdown in growth was influenced by various global factors, including the lingering effects of the COVID-19 pandemic, supply chain disruptions, and geopolitical conflicts in key regions, which affected international trade and investment patterns. Despite these headwinds, certain sectors showed resilience, with technology and healthcare continuing to perform strongly. However, industries more sensitive to interest rates, such as real estate and consumer goods, experienced more significant impacts. The mixed performance across different sectors reflects the uneven impact of the prevailing economic conditions.

Looking ahead to 2023, there's a widespread expectation of a further slowdown in global economic growth. Analysts predict a modest 1.5% expansion, as the factors that dampened growth in 2022, particularly inflation and geopolitical tensions, are likely to persist. This projection is underpinned by concerns about ongoing supply chain issues and the potential for further disruptions in international trade.

In the energy sector, 2022 saw a notable increase in worldwide oil demand, estimated at 2.5 million barrels per day (mmbpd), bringing the total to 99.8 mmbpd. This rise in demand can be partly attributed to the global economic recovery following the pandemic, as industries ramped up production and transportation needs increased. However, this surge in demand was met with an ample supply, with the global oil supply estimated to have averaged 100.8 mmbpd.

Despite this seemingly oversupplied position, the ICE Brent crude oil price averaged \$99 per barrel in 2022, a significant increase of approximately 39.8% compared to the average of \$71 per barrel in 2021. This rise in oil prices was driven by a combination of factors, including production cuts by major oil-producing countries, geopolitical tensions affecting oil-producing regions, and fluctuations in currency values that impacted global oil trade. Additionally, market conditions in the first half of the year, characterized by high demand and concerns over supply disruptions, pushed prices to a peak of \$128 per barrel.

The fluctuating oil prices had wide-ranging implications for the global economy. Higher energy costs contributed to the overall inflationary pressures, impacting both businesses and consumers. Transportation and manufacturing sectors, in particular, felt the strain of increased operational costs. On the other hand, oil-producing countries benefited from higher revenues, which could potentially be reinvested into diversifying their economies or stabilizing their financial positions.

In conclusion, 2022 was a year marked by significant economic challenges, yet the global economy demonstrated a level of resilience. The energy sector, particularly oil, played a pivotal role in shaping economic conditions, with its dynamics reflecting broader global trends. As we move into 2023, the lingering effects of these challenges, alongside new developments, will continue to shape the global economic and energy landscapes.

# Original text from Annual Report

## Commitment to act responsibly

Sustainability is embedded within the Aramco strategy. The long-term sustainability of the business will be driven by the Company's ability to leverage its competitive position while reducing its emissions. Acting responsibly across all aspects of its business will enable Aramco to successfully navigate and benefit from a lower emissions future.

### Sustainability governance

Aramco's Board of Directors oversee sustainability efforts through the Sustainability, Risk and Health, Safety and Environment (HSE) Committee. The Committee reviews and provides oversight on sustainability, risk and HSE policies and practices to ensure they are discussed, understood, owned, and promoted at the Board level. The Committee receives quarterly updates from management regarding the Company's performance across a range of sustainability key performance indicators (KPIs), and provides oversight with respect to strategy, goals, and important areas of focus. The Sustainability, Risk and HSE Committee reports its findings to the Board.

At a management level, the Company's Sustainability Steering Committee (SSC) aligns all sustainability-related activities under the guidance and oversight of a single body. The SSC is comprised of Aramco Senior Vice Presidents representing business lines and administrative areas, and is led by the Executive Vice President of Strategy and Corporate Development. The SSC reports to both the Strategy Council and Management Committee, and is responsible for identifying sustainability issues and their impact on long-term value creation for the business and stakeholders. See Section 4: Risk for more information on Aramco's risk management framework, and Section 5: Corporate governance for the Sustainability, Risk and HSE Committee Report.

### Four areas of focus

Aramco has identified the following four sustainability focus areas to oversee its sustainability performance:

- Climate change and the energy transition;
- Safe operations and people development;
- Minimizing environmental impact; and
- Growing societal value.

Aramco takes both a strategic and operational approach as it seeks to address these significant areas, and has identified KPIs for each focus area. A high-level overview of the 2022 sustainability performance is provided in this section. Aramco will elaborate on its overall sustainability performance and plans in its upcoming 2022 Sustainability Report.

## Strong inclusion of AI for 2023

In 2023, Aramco has further embedded sustainability within its strategy, with a significant new dimension: the intensive use of responsible Artificial Intelligence (AI) in all major business processes. This approach underscores the company's commitment to long-term sustainability, driven by leveraging its competitive position while responsibly reducing emissions. Aramco's integration of innovative Generative AI technologies, used ethically and transparently, marks a new era in its operational efficiency and environmental stewardship.

Sustainability governance has evolved to include the oversight of AI applications. The Board of Directors, through the Sustainability, Risk and Health, Safety and Environment (HSE) Committee, now also examines the ethical deployment of AI in sustainability efforts. This committee ensures AI technologies are discussed, understood, and promoted at the Board level. They receive quarterly updates on AI-enhanced sustainability key performance indicators (KPIs), providing critical oversight on strategy and goals in this new technological frontier.

At the management level, the role of the Company's Sustainability Steering Committee (SSC) has expanded. Now, in addition to aligning sustainability activities, it oversees the integration and ethical use of AI across the company. The SSC, comprising Senior Vice Presidents from various business lines and led by the Executive Vice President of Strategy and Corporate Development, reports on AI advancements to both the Strategy Council and Management Committee. This body is crucial in identifying sustainability issues and their interplay with AI, focusing on long-term value creation for the business and stakeholders.

Refer to Section 4: Risk for more on Aramco's AI-enhanced risk management framework, and Section 5: Corporate governance for the detailed Sustainability, Risk and HSE Committee Report incorporating AI governance.

Four areas of focus: Aramco's commitment to sustainability and AI integration is evident in its four key focus areas:

- Climate change and the energy transition, with AI-driven solutions;
- Safe operations and people development, enhanced by AI analytics;
- Minimizing environmental impact through AI-optimized processes; and
- Growing societal value, leveraging AI for community engagement and support.

Each area now includes AI-specific KPIs, reflecting Aramco's pioneering approach in harmonizing AI innovation with sustainable development goals.

## Change in focus of the 2022 document for 2023

## Moderate inclusion of AI for 2023

In 2023, Aramco's strategy continues to be deeply rooted in sustainability, with a notable enhancement: the moderate yet impactful integration of responsible Artificial Intelligence (AI) into its major business processes. This evolution underscores Aramco's commitment to balancing long-term sustainability with technological innovation, particularly through the ethical and transparent use of AI. The company's focus remains on leveraging its competitive position and reducing emissions, now augmented with AI to enhance efficiency and decision-making processes.

Sustainability governance at Aramco has adapted to this technological shift. The Board of Directors, through its Sustainability, Risk and Health, Safety and Environment (HSE) Committee, now includes the oversight of AI applications in its remit. This committee ensures that the use of AI in sustainability initiatives is consistent with Aramco's ethical standards, aligning with the company's long-standing commitment to responsible business practices. The inclusion of AI is carefully managed to complement, rather than overshadow, the core sustainability objectives.

At the management level, the Company's Sustainability Steering Committee (SSC) plays a crucial role in integrating AI into sustainability efforts. The SSC, comprising Senior Vice Presidents from different business lines, ensures that AI tools are used to optimize sustainability outcomes while being cognizant of their broader impacts. The Executive Vice President of Strategy and Corporate Development, who leads the SSC, ensures that AI applications are aligned with both Aramco's sustainability goals and ethical standards.

See Section 4: Risk for more information on Aramco's risk management framework, now enhanced with AI insights, and Section 5: Corporate governance for the detailed Sustainability, Risk and HSE Committee Report, which includes aspects of AI governance.

Four areas of focus: Aramco maintains its dedication to sustainability, now with a moderated AI integration, across four key areas:

- Climate change and the energy transition;
- Safe operations and people development;
- Minimizing environmental impact; and
- Growing societal value.

In each area, AI plays a supportive role, augmenting Aramco's capabilities in monitoring, analysis, and strategic planning, thereby reinforcing its commitment to sustainability and responsible business practices.

### Example – inclusion of AI in Aramco for 2023:

The major addition should be intensive usage of responsible Artificial Intelligence into all major business processes of the Aramco company. Emphasize the innovative capabilities of Generative Artificial Intelligence. Emphasize ethical and transparent use of AI.



Is more  
traditional AI  
still relevant?

...yes, in many aspects





# What remained from a more traditional AI?

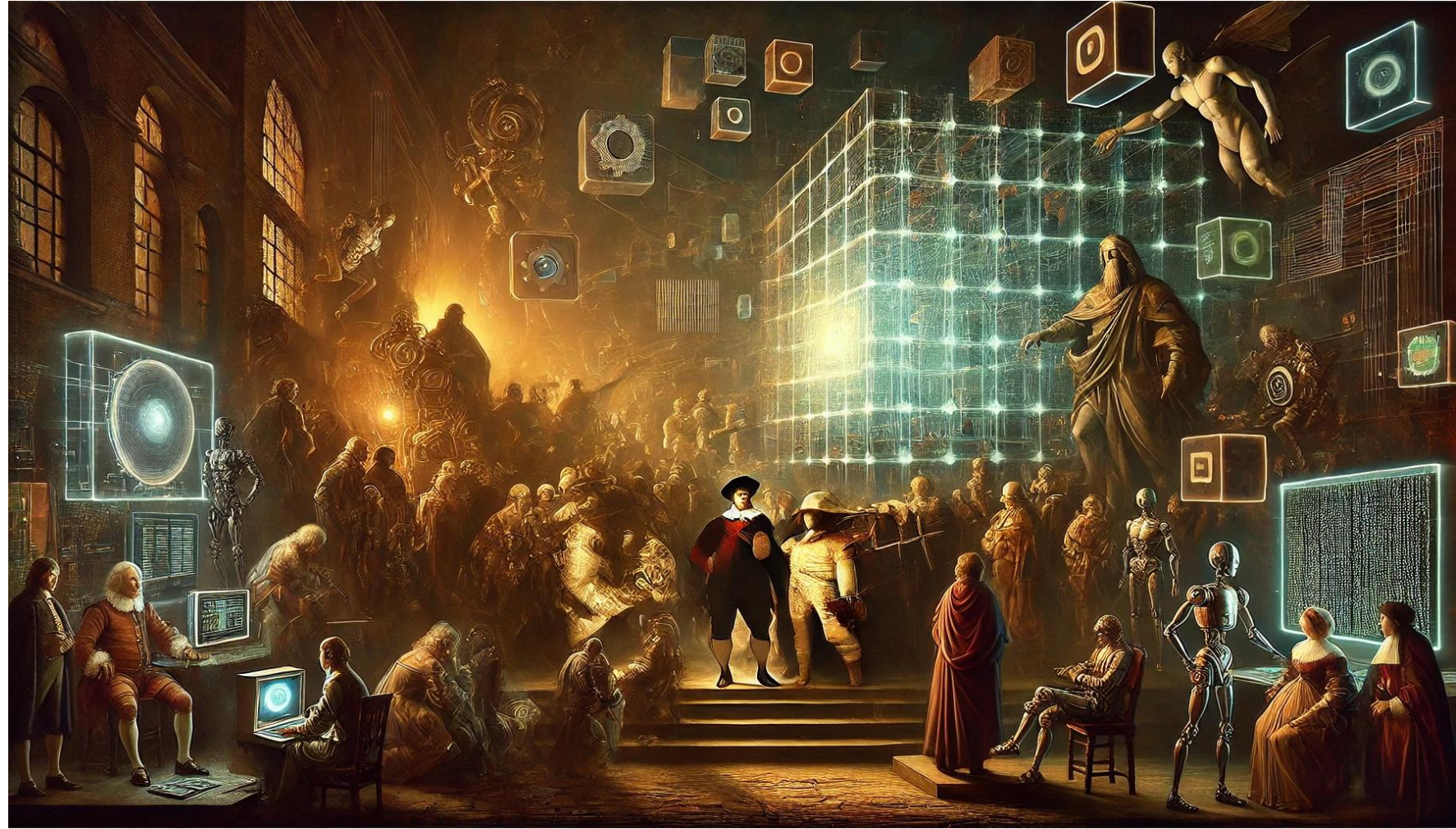
- Non-GenAI/LLM type of AI still exists and is still very useful!
  - ...due to the GenAI hype “old-AI” lives in a shadow, but generates lots of value
- Traditional AI is based largely on statistical methods (+search/optimization) and on logic
  - ...it can be often understood as a “narrow AI”



# ...as a reminder – examples of “Traditional AI”?

<b><i>Approach</i></b>	<b><i>Properties</i></b>	<b><i>Example Use Cases</i></b>
<b>Regression Models</b> (GLM, Bayesian)	Explainable AI, Theoretical Guarantees	GDP forecasting, small area estimation
<b>Probabilistic Graphical Models</b>	Explainable AI, Reasoning	Causal inference, economic projections
<b>Decision Trees</b> (Random Forest, XGBoost)	Scalable, Partial Explainability	Tax fraud detection, sector classification
<b>Linear/Integer Programming</b>	Rigorous AI, Theoretical Guarantees	Budget allocation, survey scheduling
<b>Big Data AI</b> (Hadoop, Online Learning)	Big Data AI, Scalable, Real-Time	Census processing, stock market monitoring
<b>Explainable AI</b> (SHAP & LIME)	Explainable AI	Credit scoring, GDP modeling audits
<b>Digital Twins</b>	Dynamic systems, Explainable AI	Urban planning, macroeconomic simulation
<b>Reasoning AI / Semantic Web</b> (Fuzzy Logic, Ontologies)	Reasoning Techniques, Explainable AI	AI compliance, subjective well-being analysis
<b>Real-Time AI</b> (CEP, Kalman Filters)	Real-Time AI, Scalable	Economic shock detection, live traffic monitoring



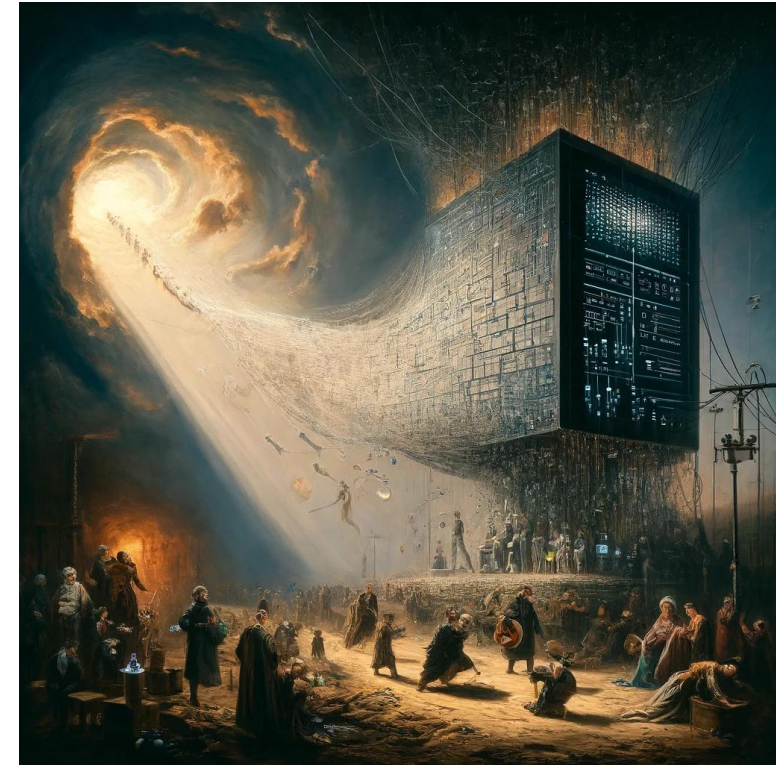


Technical triggers of AI  
endangering human rights

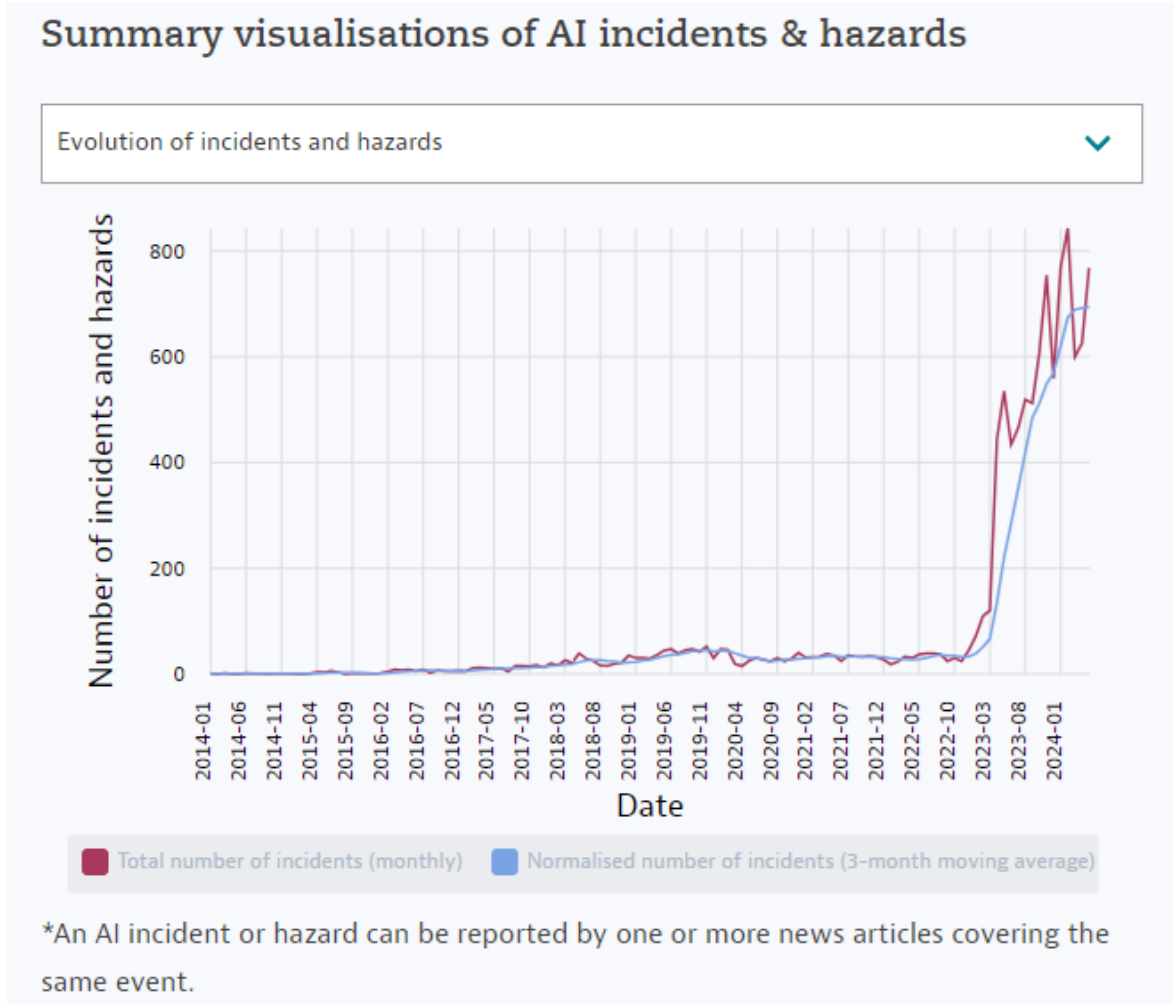


# (Some of) the basic properties of AI systems which could endanger human rights

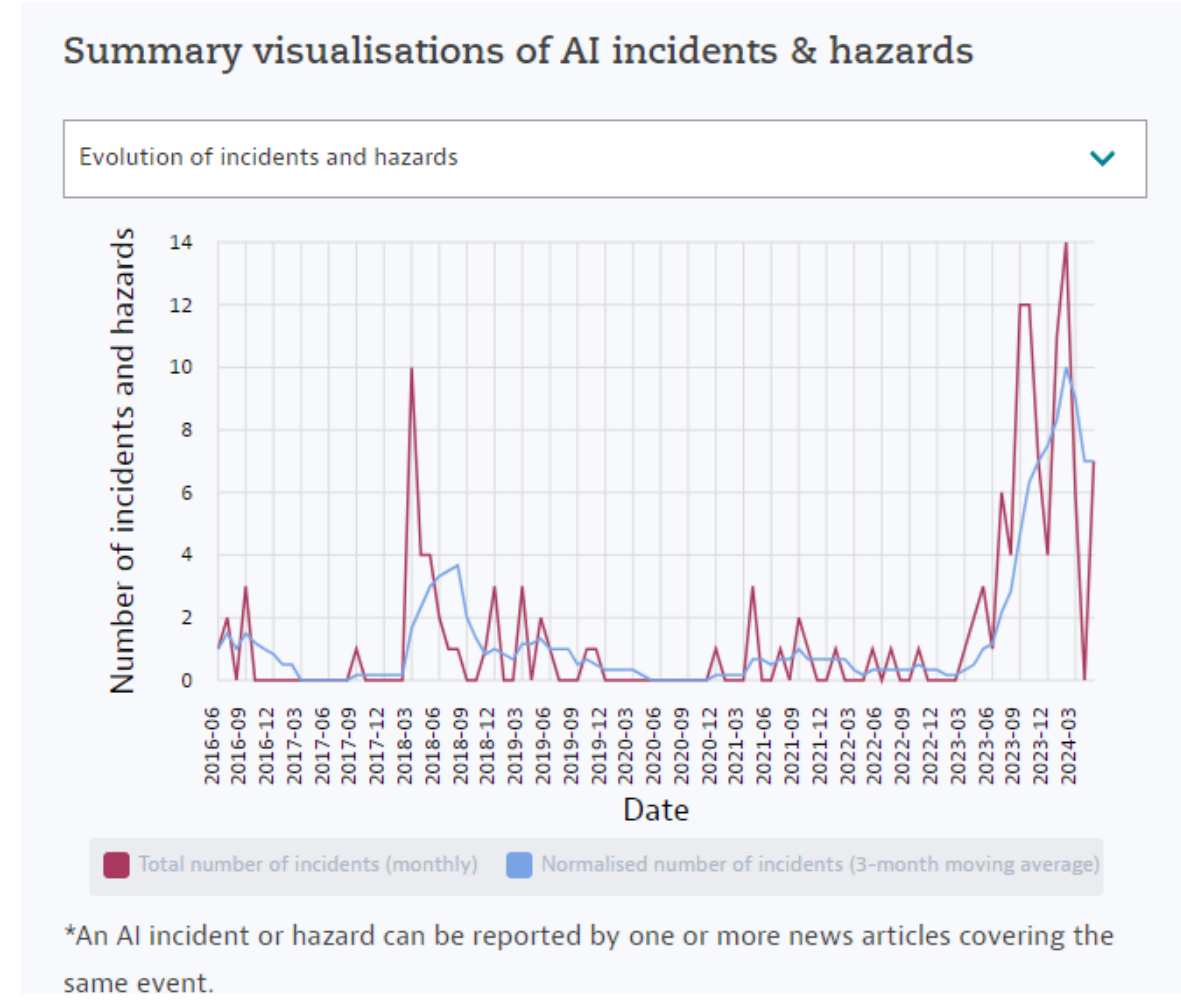
- **Managing large scale of complexity (recursive AI agents)**
  - ...using the scale of data in the size of all human digital content
  - Humans cannot manage complexity beyond certain scale
- **Black-box models / lack of transparency**
  - ...suitable for machine, but not for human
  - Humans don't have feedback into machine (by explanation)
- **Speed of inferencing**
  - Surpassing humans in reaction time
  - The Speed of computers increases ~4 times per year
- **Autonomous Decision-Making (Human 'Out of Loop')**
  - ...due to misalignment of human vs. machine value systems
- **Unclear accountability**
  - ...the chain of stakeholders in the process is long
- **Robustness**
  - ...AI systems are not perfect and is hard to guarantee stable results



# Brief statistics of AI incidents (<https://oecd.ai/incidents>)



Overall number of incidents increased after 2022



Number of deaths and physical harm stayed mostly stable



# Likely future AI developments





# Speed of computers: computers are ~4 times faster every year

- If computers will be expectedly much faster in the near future, what can we do with such capacity?
- ...what fundamental AI problems could be addressed and what consequences this could have?



Jensen Huang, NVIDIA CEO, March 19, 2024:

"Moore's Law, in its best days, would have delivered 100x in a decade," Huang explained. "By coming up with new processors, new systems, new interconnects, new frameworks and algorithms and working with data scientists, AI researchers on new models, across that entire span, we've made large language model processing a million times faster."

<https://siepr.stanford.edu/news/nvidias-jensen-huang-incredible-future-ai>

<https://www.youtube.com/watch?v=cEg8cOx7UZk>

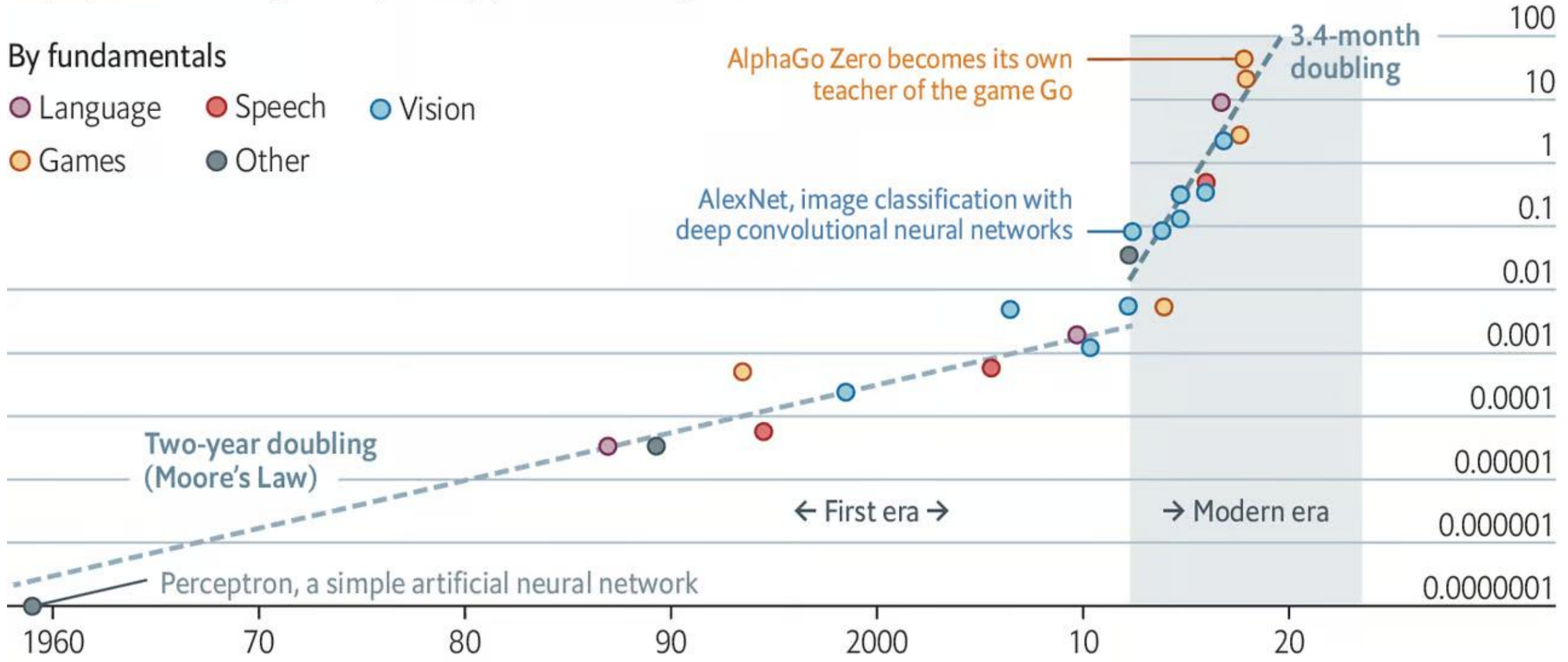


# Deep and steep

Computing power used in training AI systems  
Days spent calculating at one petaflop per second\*, log scale

By fundamentals

- Language
- Speech
- Vision
- Games
- Other

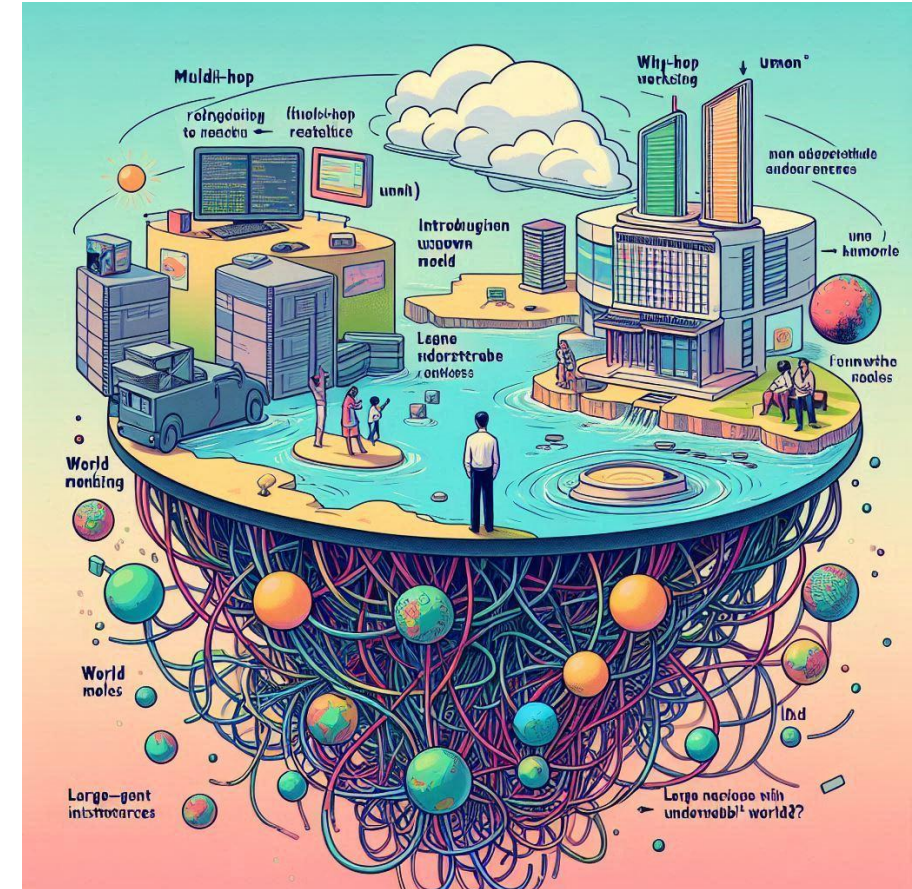


Source: OpenAI

\*1 petaflop=10<sup>15</sup> calculations

# (Near- to Mid-)future AI challenges

1. **Advanced reasoning capabilities** to reach *(un)known (un)known knowledge*
2. **Why** GenAI/LLMs works at all?
3. Introducing “**World Models**” to relate with human understandable world
4. Large **(recursive) AI agent** infrastructures with autonomous emergent behaviors
5. Integrating new **data modalities (types of data)** beyond the usual ones



First-Order-Logic World-Model  
grounding

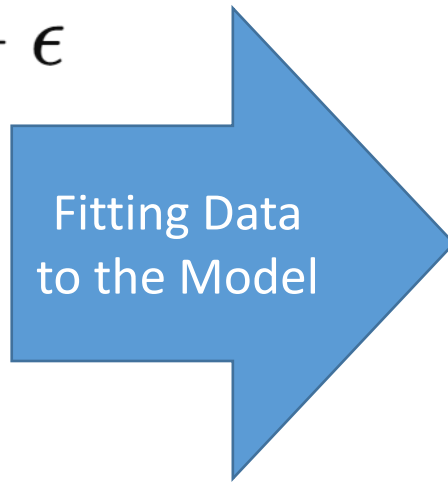
**Reminder:** Traditional process of fitting data to a model  
– analogy to be used on the text

**Model:**

$$y = \beta_0 + \beta_1 x + \epsilon$$

**Data:**

x	y
1	50
3	60
4	70
6	80
8	90



The intercept ( $\beta_0$ ) of the line is approximately 44.38.  
The slope ( $\beta_1$ ) of the line is approximately 5.82.

$$y = 44.38 + 5.82x$$

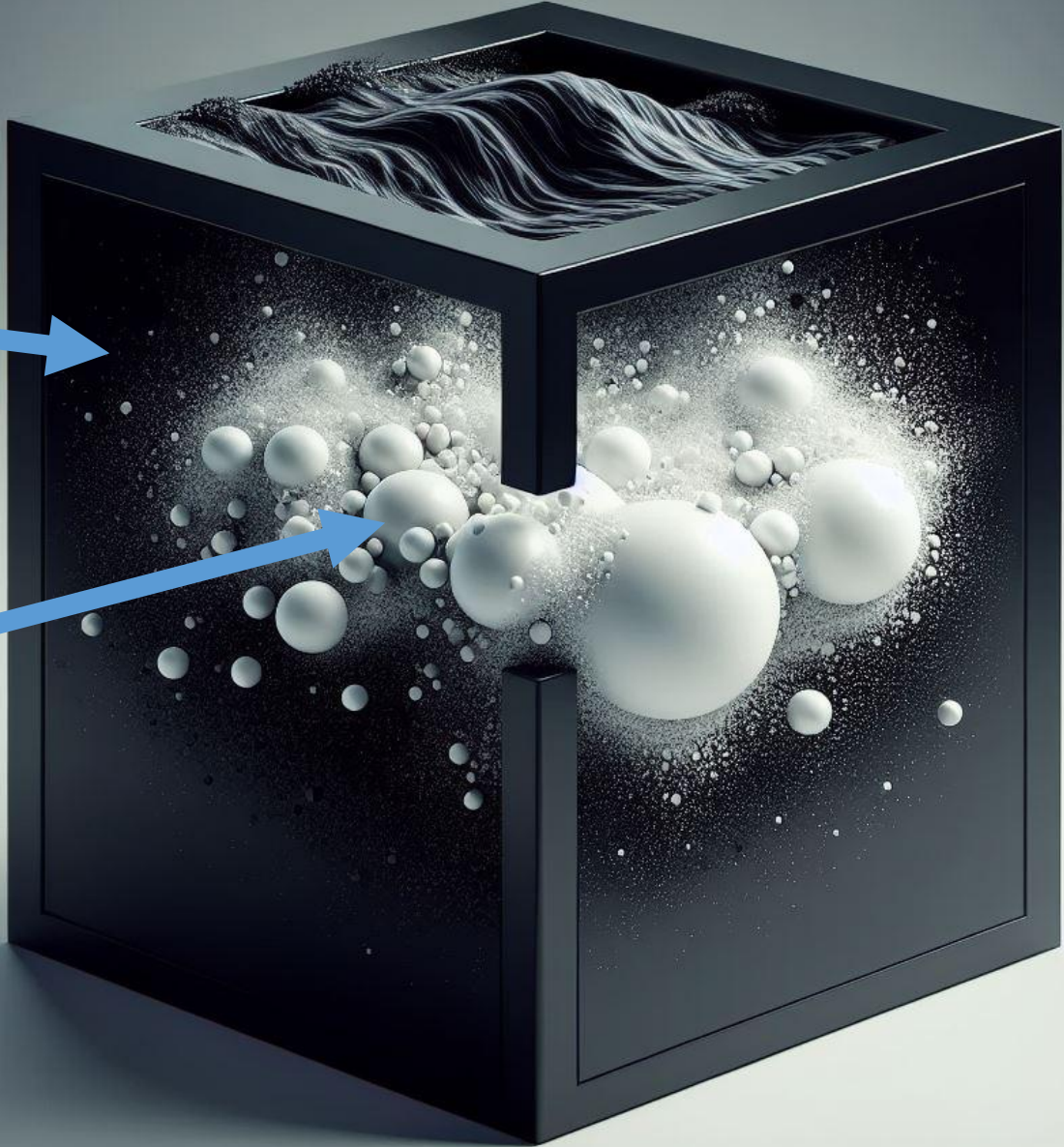
...instead of a numeric regression model we want to have a First-Order-Logic model, and instead of data we want to use plain text – model fitting to be done by LLM based system



# LLMs & World Models

LLM as a  
big black-box

Fragments of  
explainable  
knowledge  
(via local “world models”)



# First, we develop small World-Model on “*Company having a motive to acquire another company*”

**Prompt:** create rich prolog definition of the concept "company having a motive to acquire another company". Use atomic subpredicates, possibly taken from OpenCyc common sense vocabulary.

```
acquisition_motive(Acquirer, Target) :-  
    acquisition_motive_expansion(Acquirer, Target);  
    acquisition_motive_diversification(Acquirer, Target);  
    acquisition_motive_technology(Acquirer, Target);  
    acquisition_motive_revenue(Acquirer, Target);  
    acquisition_motive_market_dominance(Acquirer, Target)
```

```
acquisition_motive_expansion(Acquirer, Target) :-  
    seeking_expansion(Acquirer, expansion),  
    potential_for_growth(Target).
```

```
acquisition_motive_diversification(Acquirer, Target) :-  
    desire_for_diversification(Acquirer, diversification),  
    not(dominant_in_market(Target, Market)),  
    company(Target),  
    market_position(Acquirer, Position),  
    Market \= Position.
```

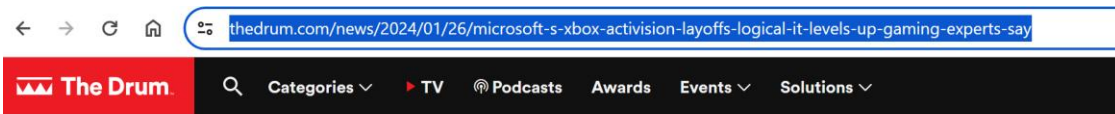
```
acquisition_motive_technology(Acquirer, Target) :-  
    seeking_technological_advancement(Acquirer, technological_advancement),  
    has_technology(Target, Technology),  
    not(has_technology(Acquirer, Technology)).
```

```
acquisition_motive_revenue(Acquirer, Target) :-  
    interest_in_revenue_increase(Acquirer, Target, revenue_increase),  
    financial_stability(Target, high),  
    revenue(Target, Amount),  
    Amount > 1000000. % Example threshold
```

```
acquisition_motive_market_dominance(Acquirer, Target) :-  
    seeking_market_dominance(Acquirer, market_dominance),  
    dominant_in_market(Target, Market),  
    compatible_company(Acquirer, Target).
```

# Second, we take a news article on the “acquisition”

<https://www.thedrum.com/news/2024/01/26/microsoft-s-xbox-activision-layoffs-logical-it-levels-up-gaming-experts-say>



[Digital Transformation](#) [Microsoft](#) [Activision Blizzard](#)

## Microsoft gaming layoffs ‘logical’ post-Activision acquisition, experts say

Share



By Kendra Barnett | Associate Editor  
JANUARY 26, 2024 | 9 MIN READ



Listen to article 8 min 35 sec

On the tails of its acquisition of Activision Blizzard in October, the tech titan this week laid off nearly 2,000 employees from its gaming division.

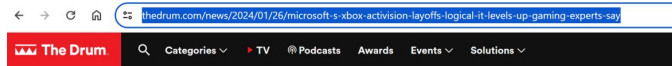


On the tails of its acquisition of Activision Blizzard in October, the tech titan this week laid off nearly 2,000 employees from its gaming division. Microsoft building Microsoft is gearing up to compete more aggressively in the gaming industry / Adobe Stock Microsoft laid off 1,900 employees from its Xbox and Activision Blizzard divisions this week – just three months after the company completed its \$68.7bn acquisition of Activision Blizzard. The cuts represent about 8.6% of Microsoft’s gaming staff. The news comes in a string of layoffs that have rocked the tech world in the last year and a half. “It’s a very difficult time for publishers, developers, studios and gaming tech platforms, as more and more layoffs continue to materialize,” says Alex Ginn, vice-president of demand, UK and EMEA at iion, an advertising platform for brands and game publishers. “However,” he says, “the actual consumer market is ever buoyant and positive.” He’s right. Data from the US Commerce Department released last month indicates that, despite an outsized number of layoffs in the tech and media space of late, the economy at large is looking healthy. Consumer spending is high and, in the fourth quarter, gross domestic product grew at the annualized rate of 3.3%, following a Q3 growth rate of 4.9%. The robust state of the US economy makes major waves of tech layoffs all the more perturbing. “These losses are painful,” says Greg Kahn, chief executive officer at GK Digital Ventures and an expert in emergent technology and media. “And these layoffs most of us consider jarring in light of healthy economic numbers showing inflation stabilizing along with decent GDP growth.” In the gaming space in particular, there may be a variety of contributing factors. For one, the boom of mobile, console and PC gaming during the early days of the pandemic may have led to “over-exuberant hiring and spending,” says Harry Lang, vice-president of marketing at Kwalee, a UK-based video game developer. Today, Lang says, “back in the realm of reality, many firms found they were overextended – leading to these mass redundancies. It’s hurting a lot of excellent businesses and many extremely talented people.” But these factors, Lang, Kahn and Ginn all agree, were not the impetus for Microsoft’s decision to axe staffers this week. On the heels of its Activision Blizzard buyout – which faced an antitrust challenge from the US Federal Trade Commission but was ultimately given the green light – Microsoft was forced to assess its costs. As Lang puts it: “A significant reduction in headcount was one way to pay off some of the \$69bn purchase price.” In an internal company memo obtained by The Verge, Microsoft Gaming CEO Phil Spencer explained to staffers that the layoffs are part of a larger plan to “[identify] areas of overlap” post-acquisition. It’s a development that Ginn says he predicted in early 2022 when Microsoft signaled its interest in acquiring Activision Blizzard. “An expense as high as \$69bn, in this turbulent day and age for gaming, could never come without repercussions for staff on both sides of the merger,” he says. Another contributing factor may be Microsoft’s \$10bn investment in OpenAI last year and its ongoing focus on AI development internally. Google and Amazon, for example, both underwent rounds of layoffs last year at the same time that they dedicated more resources to AI development. A strategic advantage But Microsoft’s latest layoffs, according to some, also have the potential to strengthen its position in the gaming market against its biggest competitors. In short: Microsoft strengthens its bottom line if it can operate and grow its burgeoning gaming division with less overhead. “The layoffs represent the consolidation of Microsoft’s gaming division. That allows the company to turn its attention to moving forward on its competitive strategy against Sony, Nintendo, its primary gaming rivals,” says Kahn. “It’s also looking at comparative upstarts like Roblox, which has done so much to advance the gaming landscape.” It’s widely believed that much of Microsoft’s motivation in snapping up Activision Blizzard lay in its desire to take over the developer’s large content library – which includes games like Call of Duty, World of Warcraft and Candy Crush. Microsoft’s previous role in the gaming market was relegated primarily to device-making: it manufactures Xbox. But competitors like Sony and Nintendo have long operated their own gaming studios and developed games – many of which have loyal, global followings. Microsoft’s acquisition of Activision Blizzard was ultimately a strategic move designed to enable it to eat up a larger portion of the gaming market by giving it control over more intellectual property. “If there’s one thing that defines gaming success [today], it’s licensing and intellectual property, as opposed to having a best-selling console system,” Kahn told The Drum in an interview last fall. “The former is wide open in this increasingly decentralized world; the latter is limited by the constraints and trends associated with a particular hardware product.” By securing Activision Blizzard’s iconic games, he says, “Microsoft immediately is catapulted into the center of gaming with a dedicated player community, which builds on the company’s existing consoles, PC and cloud gaming offerings.” Emergent tech poses new hurdles Its newfound strength in the market doesn’t negate the fact that Microsoft will face a slate of new challenges as gaming evolves in tandem with emergent technologies. Development of cloud gaming, decentralized, blockchain-based experiences and AI-driven gaming is gaining momentum by the day. Roblox is already a leader in gaming and represents the vanguard of blockchain-based experiences. Netflix, meanwhile, is hard at work diversifying its content offerings with a growing collection of cloud-based streaming games. (The streaming platform debuted 86 games last year and has more than 90 currently in development.) Meanwhile, Apple’s Vision Pro headset is set to shake up the gaming space in significant ways. Its spate of spatial games, including Game Room, What the Golf? and Super Fruit Ninja engage players in new, immersive ways. This model of gaming could have, in Kahn’s estimation, “huge implications for collaborative and creative workplaces, healthcare, and education.” The advancement of new tech in gaming will only create new challenges for legacy gaming companies like Microsoft, Sony and Nintendo. They’re challenges that Microsoft will take in stride, Kahn predicts. He’s confident that, in 2024, “Microsoft will be accelerating its experiments in AI and immersive experiences within gaming environments.” At the same time, the company is likely looking for new ways to generate revenue from advertising and content partners. Inspired by the proliferation of commercial experiences on Roblox – where brands like Chipotle, Hilton, Adidas, Walmart and others have found success with limited-edition experiences and virtual pop-ups – Microsoft is bound to be investing in new partnership opportunities within the realm of immersive gaming. “It’s an area Microsoft has been eyeing for a while and as Apple’s Vision Pro generates more interest in mixed reality, you’re going to see Microsoft act more aggressively in that area,” Kahn says. And in light of Microsoft’s strong position in the market today, he expects that “brands and content companies are going to be responding with immediate enthusiasm.”



# Third, we ground the news article into the World-Model

```
acquisition_motive(Acquirer, Target) :-  
    acquisition_motive_expansion(Acquirer, Target);  
    acquisition_motive_diversification(Acquirer, Target);  
    acquisition_motive_technology(Acquirer, Target);  
    acquisition_motive_revenue(Acquirer, Target);  
    acquisition_motive_market_dominance(Acquirer, Target).
```



Digital Transformation Microsoft Activision Blizzard

## Microsoft gaming layoffs 'logical' post-Activision acquisition, experts say

Share



By Kendra Barnett | Associate Editor  
JANUARY 26, 2024 | 9 MIN READ

Listen to article. 8 min 35 sec

On the tails of its acquisition of Activision Blizzard in October, the tech titan this week laid off nearly 2,000 employees from its gaming division.



WorldModel +  
Text  
Grounding

% Define the companies involved

company(microsoft).

company(activision\_blizzard).

% Financial Stability

financial\_stability(activision\_blizzard, high).

% Market Position - Assuming positions based on context

market\_position(microsoft, good).

market\_position(activision\_blizzard, excellent).

% Innovation Level - Microsoft's investment in AI suggests a high innovation level

innovation\_level(microsoft, high).

% Revenue - Assumed values for demonstration

revenue(activision\_blizzard, 68700000000). % Reflecting the acquisition cost as a proxy

% Motives for Acquisition - Based on the article's context

seeking\_expansion(microsoft, expansion).

desire\_for\_diversification(microsoft, diversification).

seeking\_technological\_advancement(microsoft, technological\_advancement).

seeking\_market\_dominance(microsoft, market\_dominance).

interest\_in\_revenue\_increase(microsoft, activision\_blizzard, revenue\_increase).

% Acquisition Attributes

compatible\_company(microsoft, activision\_blizzard).

potential\_for\_growth(activision\_blizzard).

dominant\_in\_market(activision\_blizzard, gaming).

% Specific to the scenario from the article

acquisition\_motive\_technology(microsoft, activision\_blizzard).

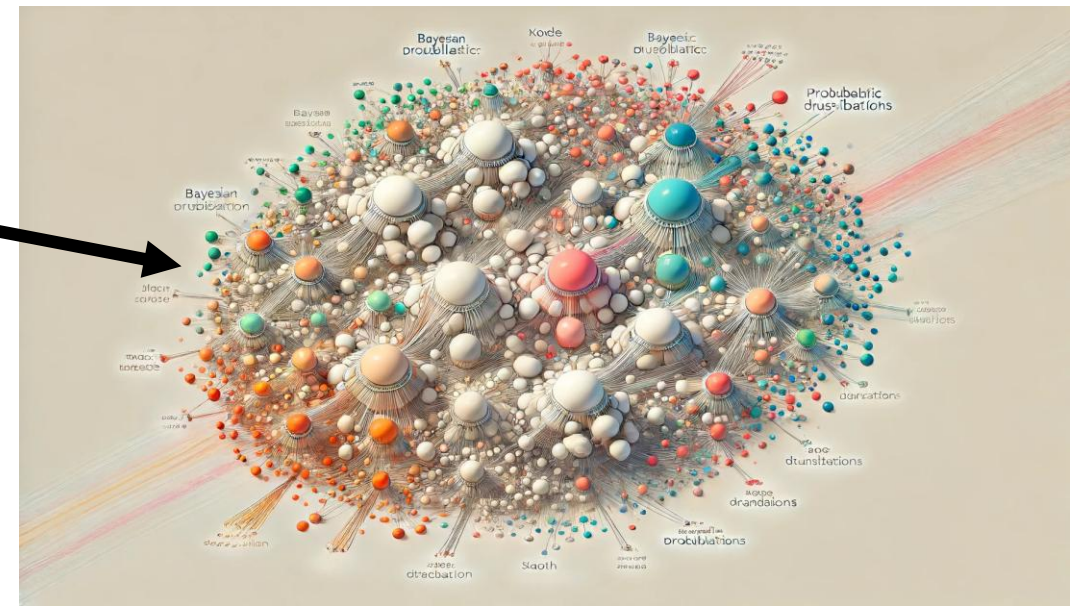
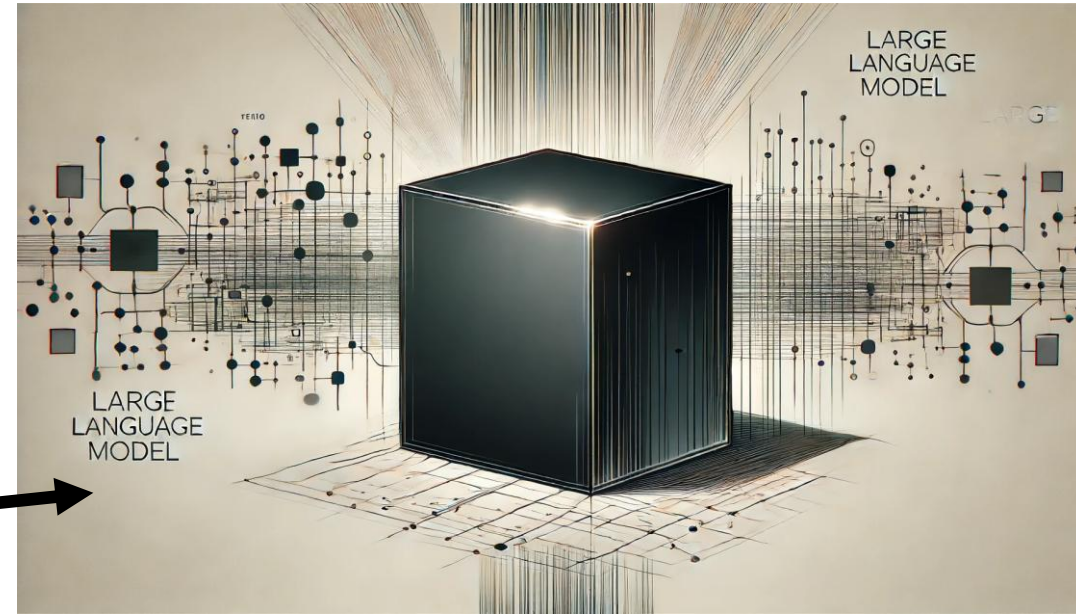
acquisition\_motive\_market\_dominance(microsoft, activision\_blizzard).

acquisition\_motive\_revenue(microsoft, activision\_blizzard).

Looking into the LLMs Brain

# How LLM models see the world?

- There is no explicit “**world model**”
  - ...i.e., machine does not understand the world
- For humans it looks like a “**big black-box**”
  - ...since it is expressed in a language not understandable by humans
- Internally the black box is a huge **network of interleaved probabilistic concepts**
  - ...could be visualized as a network of interconnected clouds representing concepts





# Example: The map of the “Inner Conflict” concept (Claude3 LLM)



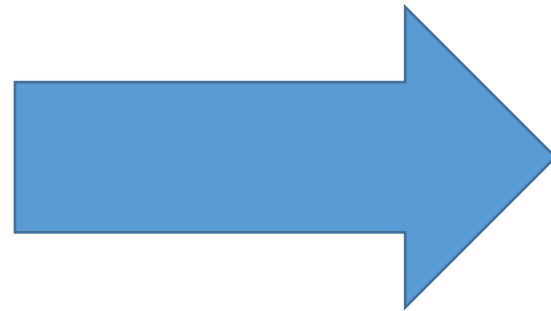


# The Hamlet Example

*Creating “World Model” from the Hamlet’s “To be or not to be ...” speech*

# Creating "World Model" from the famous Hamlet's statement

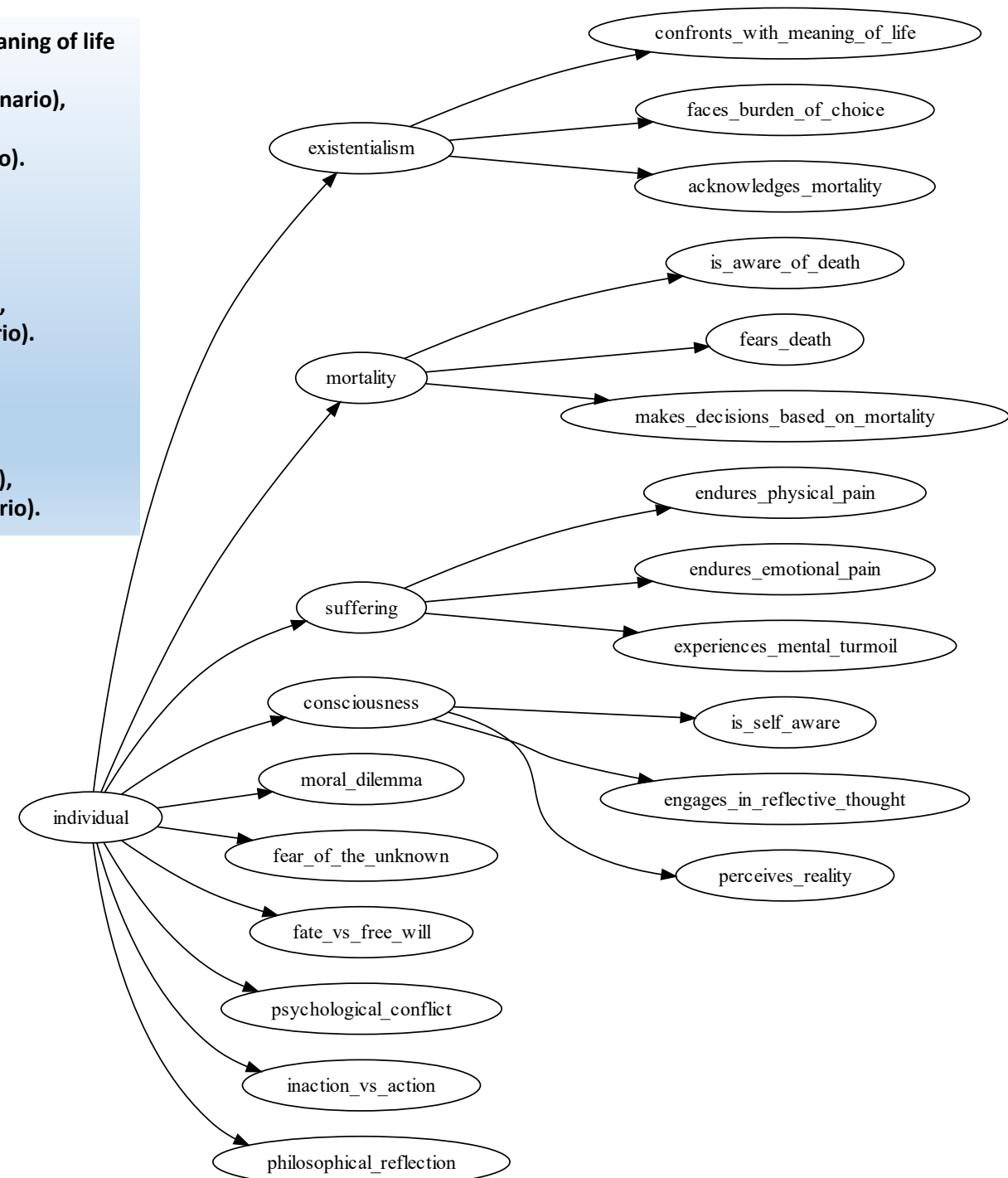
To be, or not to be, that is the question,  
 Whether 'tis nobler in the mind to suffer  
 The slings and arrows of outrageous fortune,  
 Or to take arms against a sea of troubles,  
 And by opposing end them? To die: to sleep;  
 No more; and by a sleep to say we end  
 The heart-ache and the thousand natural shocks  
 That flesh is heir to, 'tis a consummation  
 Devoutly to be wish'd. To die, to sleep;  
 To sleep: perchance to dream: ay, there's the rub;  
 For in that sleep of death what dreams may come  
 When we have shuffled off this mortal coil,  
 Must give us pause: there's the respect  
 That makes calamity of so long life;  
 For who would bear the whips and scorns of time,  
 The oppressor's wrong, the proud man's contumely,  
 The pangs of despised love, the law's delay,  
 The insolence of office and the spurns  
 That patient merit of the unworthy takes,  
 When he himself might his quietus make  
 With a bare bodkin? who would fardels bear,  
 To grunt and sweat under a weary life,  
 But that the dread of something after death,  
 The undiscover'd country from whose bourn  
 No traveller returns, puzzles the will  
 And makes us rather bear those ills we have  
 Than fly to others that we know not of?  
 Thus conscience does make cowards of us all;  
 And thus the native hue of resolution  
 Is sicklied o'er with the pale cast of thought,  
 And enterprises of great pith and moment  
 With this regard their currents turn awry,  
 And lose the name of action.--Soft you now!  
 The fair Ophelia! Nymph, in thy orisons  
 Be all my sins remember'd.



```
% Scenario: Confrontation with the meaning of life
existentialism(Scenario) :-
  confronts_with_meaning_of_life(Scenario),
  ponders_existence(Scenario),
  questions_ultimate_purpose(Scenario).

% Scenario: Burden of Choice
existentialism(Scenario) :-
  faces_burden_of_choice(Scenario),
  makes_free_will_decisions(Scenario),
  experiences_dread_of_choice(Scenario).

% Scenario: Inevitability of Death
existentialism(Scenario) :-
  acknowledges_mortality(Scenario),
  reflects_on_life_and_death(Scenario),
  struggles_with_finite_lifespan(Scenario).
```





# Hamlet's "surrenders" predicate

% Case 1: Entity gives up after a struggle or resistance

surrenders(Entity, Force) :-

resists(Entity, Force),  
overwhelmed\_by(Entity, Force),  
stops\_resistance(Entity).

% Case 2: Entity willingly ceases to pursue an objective or course of action

surrenders(Entity, Objective) :-

pursues(Entity, Objective),  
faces\_obstacle(Entity, Obstacle),  
considers(Entity, Obstacle),  
judges(Entity, Objective, unattainable),  
gives\_up(Entity, Objective).

% Case 3: Entity concedes to another's will or demand without further conflict

surrenders(Entity, Demand) :-

confronted\_by(Entity, Demander),  
presented\_with(Demander, Demand),  
evaluates(Entity, Demand),  
decides(Entity, comply),  
ceases\_opposition(Entity, Demand).

% Case 4: Entity accepts a fate or condition without further resistance

surrenders(Entity, Fate) :-

faces(Entity, Fate),  
realizes(Entity, inevitable(Fate)),  
accepts(Entity, Fate),  
stops\_resistance(Entity).

% Case 5: Entity relinquishes control or power over something

surrenders(Entity, Control) :-

has\_control(Entity, Control),  
loses(Entity, Control),  
willingly\_relinquishes(Entity, Control).

# Instantiating document into Hamlet's World Model

<https://www.nytimes.com/2024/08/14/us/politics/biden-retirement.html>

## *'I'm Looking for a Job': Biden Jokes About Life After the White House*

With a jovial serenity, the president has more publicly embraced the idea of retirement as he heads into his final months in office.

```
% Instantiation of existential_uncertainty/1 based on the provided text
existential_uncertainty(biden) :-
    is_conscious_being(biden),
    contemplates_existence(biden, ["life after presidency", "future roles"]),
    encounters_moral_dilemmas(biden, ["balancing legacy with current duties"]),
    fears_unknown(biden, ["uncertain future after retirement"]),
    experiences_psychological_conflict(biden, ["letting go of power vs continuing to serve"]),
    perceives_life_suffering(biden, ["pressure of ongoing responsibilities"]),
    questions_afterlife(biden, ["future impact", "legacy"]).
```

```
% Example of atomic predicates for this scenario
```

```
% Biden as a conscious being
is_conscious_being(biden).
```

# *Grounding JetLag article into Hamlet's World Model*

<https://www.nytimes.com/article/jet-lag-prevention.html>

## **How to Handle Jet Lag, According to Very Frequent Travelers**

A long flight can be exhausting, but recovering from it needn't take up half your trip.



**is\_human(traveler):** The subjects in the text are human travelers.

**has\_consciousness(traveler):** Travelers are aware of their physical and mental state, reflecting on how to handle jet lag.

**seeks\_meaning(traveler) and defines\_own\_meaning(traveler):** Travelers seek to find meaning in their travel experiences, optimizing their routines to minimize the negative impact of jet lag.

**faces\_freedom(traveler):** Travelers have the freedom to choose how they adapt to new time zones and environments.

**makes\_choices(traveler):** They make choices to manage jet lag effectively, like adjusting sleep schedules and diet.

**experiences\_anxiety(traveler):** Jet lag induces anxiety, fatigue, and other discomforts, which travelers must cope with.

**experiences\_suffering(traveler):** Physical symptoms like fatigue and irritability represent the suffering travelers endure.

**challenges\_societal\_norms(traveler):** Travelers may adopt unconventional methods to combat jet lag, challenging norms like meal times or sleep patterns.

**confronts\_absurdity(traveler):** The absurdity of jet lag is acknowledged, but travelers still define their own methods to deal with it.

**faces\_crisis(traveler):** The disruption caused by jet lag can be seen as a crisis that travelers must manage.

**redefines\_values(traveler):** Travelers may redefine their routines and values to better handle the challenges of travel.

**takes\_responsibility(traveler):** Travelers take personal responsibility by following strategies to mitigate the effects of jet lag.

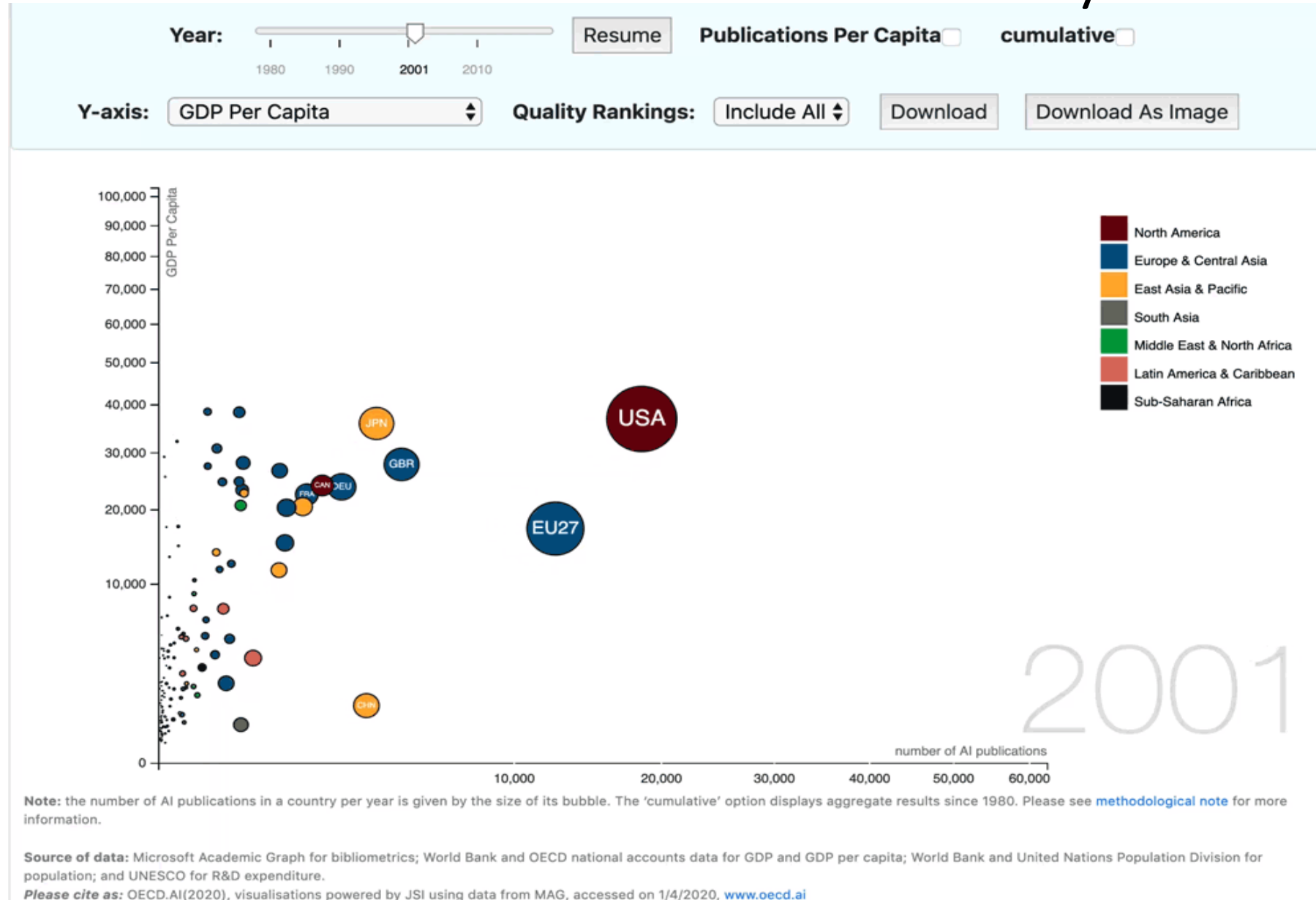


# Brief insights into the geopolitics of AI

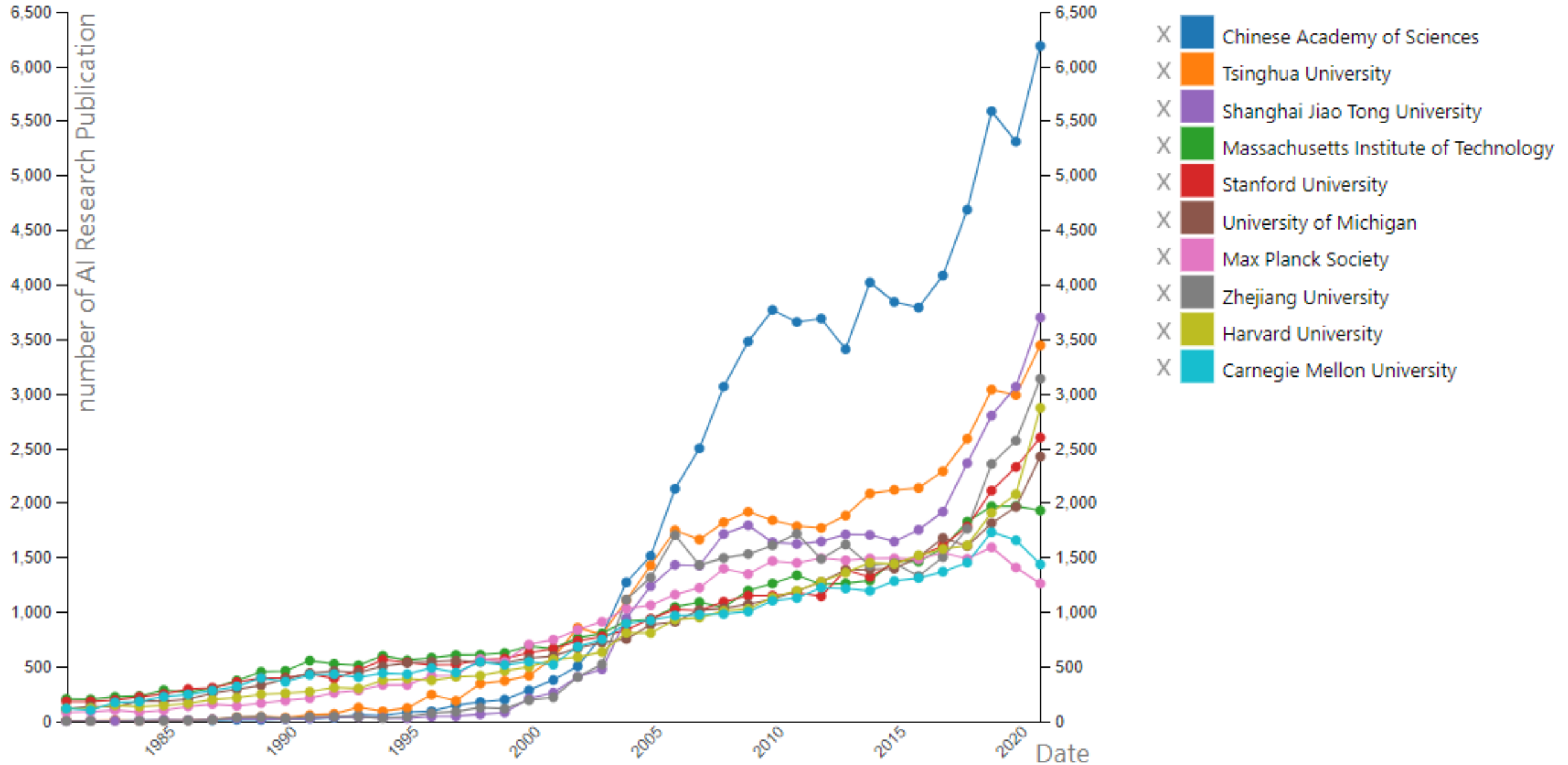
USA, China and Europe competing



# Production of AI research over years

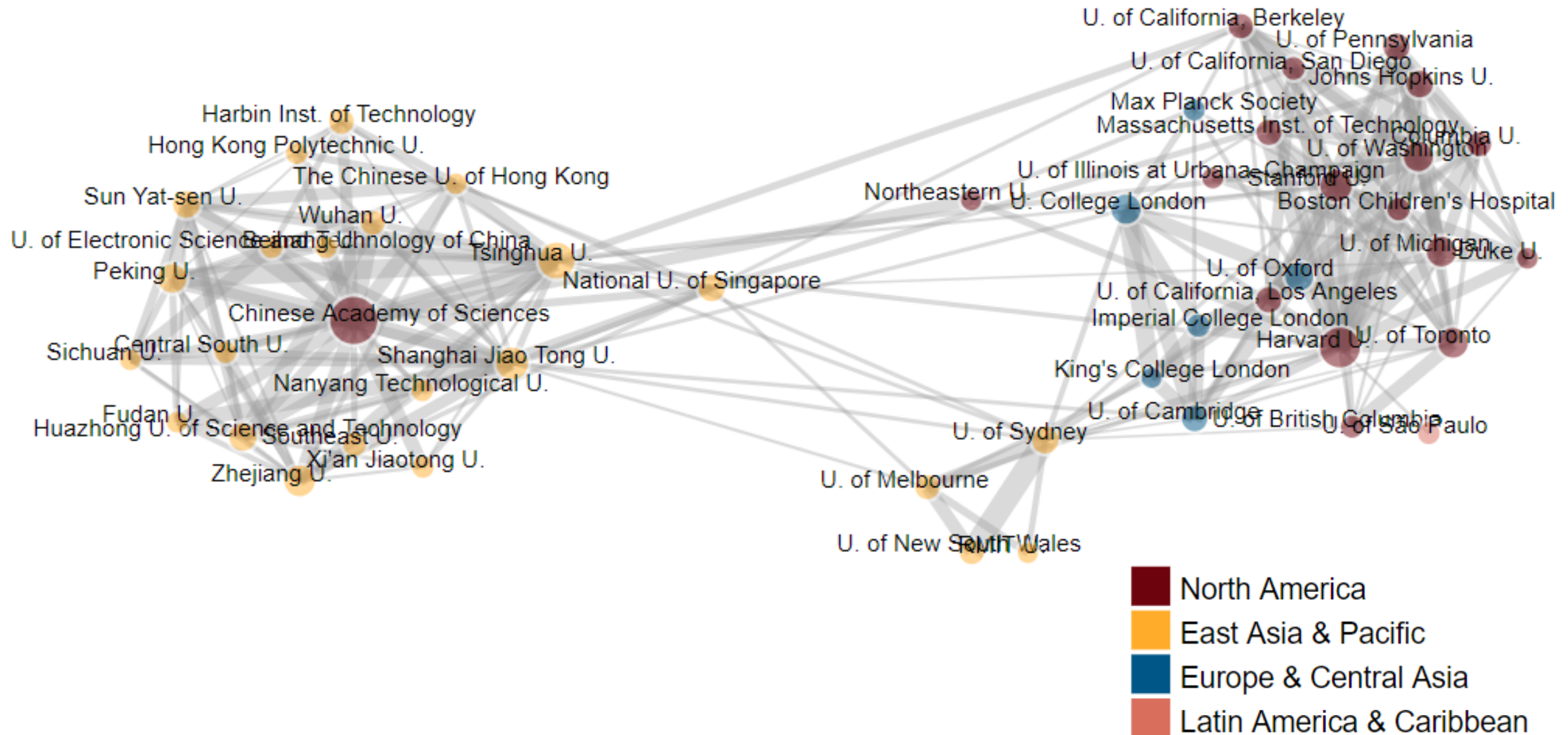


# AI Research per institution

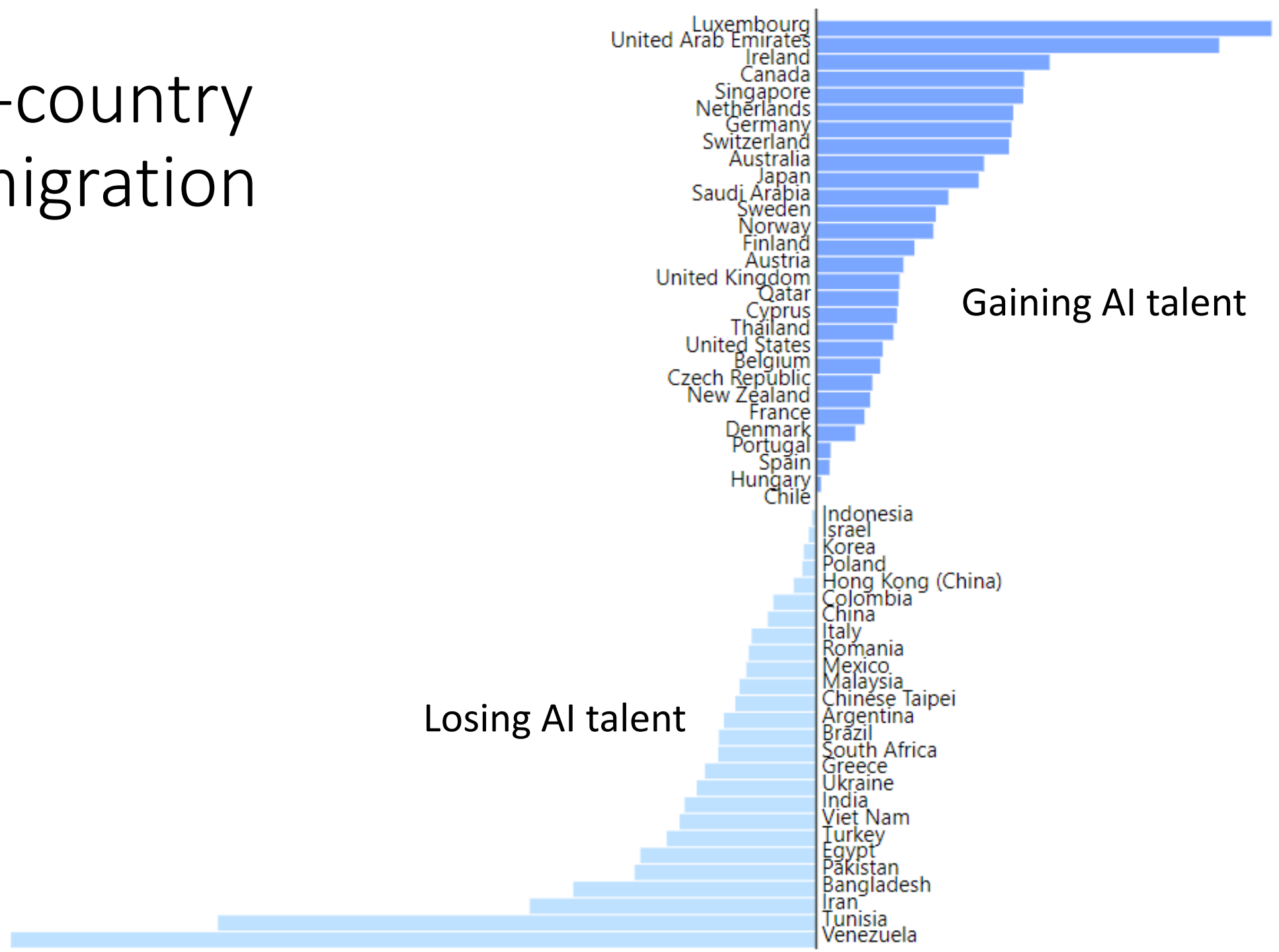


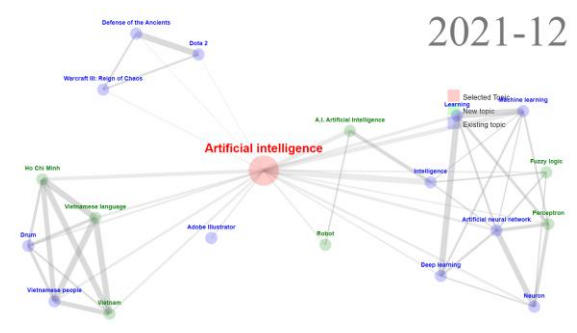
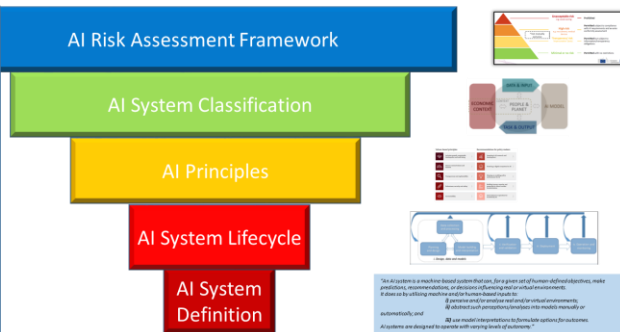


# AI Research collaboration between institutions

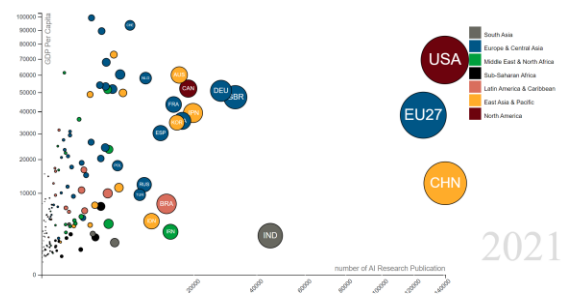


# Between-country AI skills migration

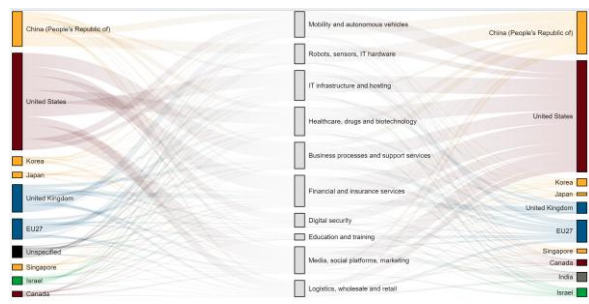
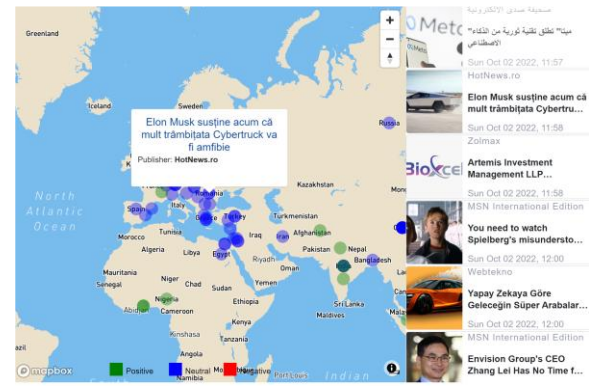




2021-12



2021



# How AI Innovations propagate

Near real-time observation of the evolution of AI across the ecosystem

<https://oecd.ai/>



# Real-Time Technology Watch

## *“a journey of an innovation”*



- “OECD AI Policy Observatory” (<https://oecd.ai/>)
- Main objectives of the use case are to build a platform to respond on questions related to the global innovation ecosystem in the area of AI
  - *To understand the evolution of AI?*
  - *To detect impactful innovations early in the process?*
  - *To predict what will be ‘the next big thing’ in AI?*
  - *Building aka ‘the digital twin of AI ecosystem’*
- The basic premise is that ideas and innovations which will impact our lives in the next 5-10 years are already invented and published...

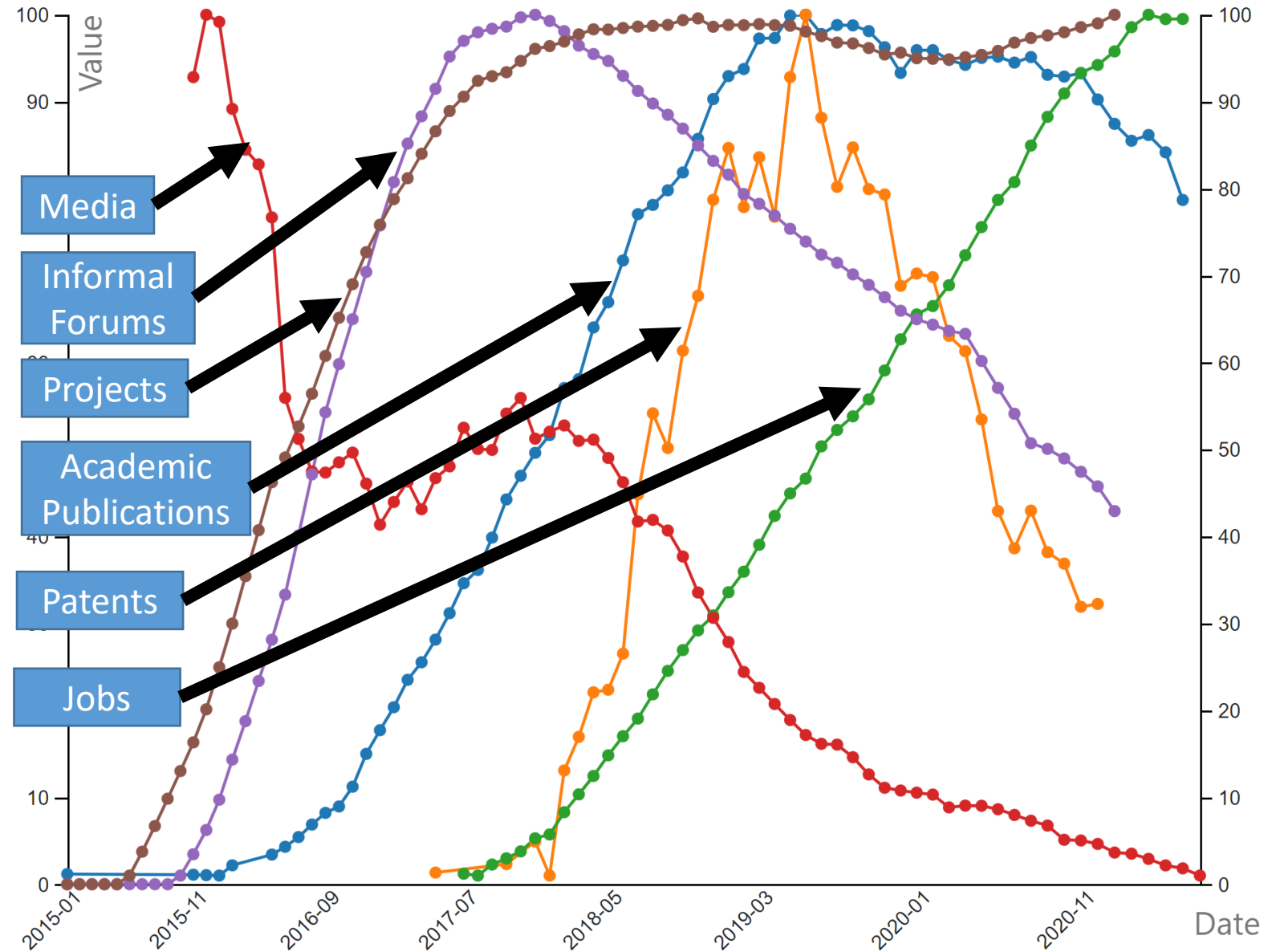
# OECD AI Policy Observatory narrative:

Tracking an innovation across many stages of the ecosystem

- An innovation **spotted in the academic world**...
- ...**projects** are started around the innovation (publicly funded, open source)
- ...researchers & developers **informally discuss** the innovation
- ...the innovation gets **patented**
- ...**companies** are established around the innovation
- ...companies get **investments**, possibly in several rounds
- ...investments have influence on **job market** (supply and demand side)
- ...**market** reacts on the quality of innovation
- ...**education** introduces new courses
- ...**perception** & interest from expert and broad audiences
- ...**media** starts publishing about the innovation and companies
- ...**incidents** happen to show weaknesses to be treated
- ...**policies** are formulated on international and national level

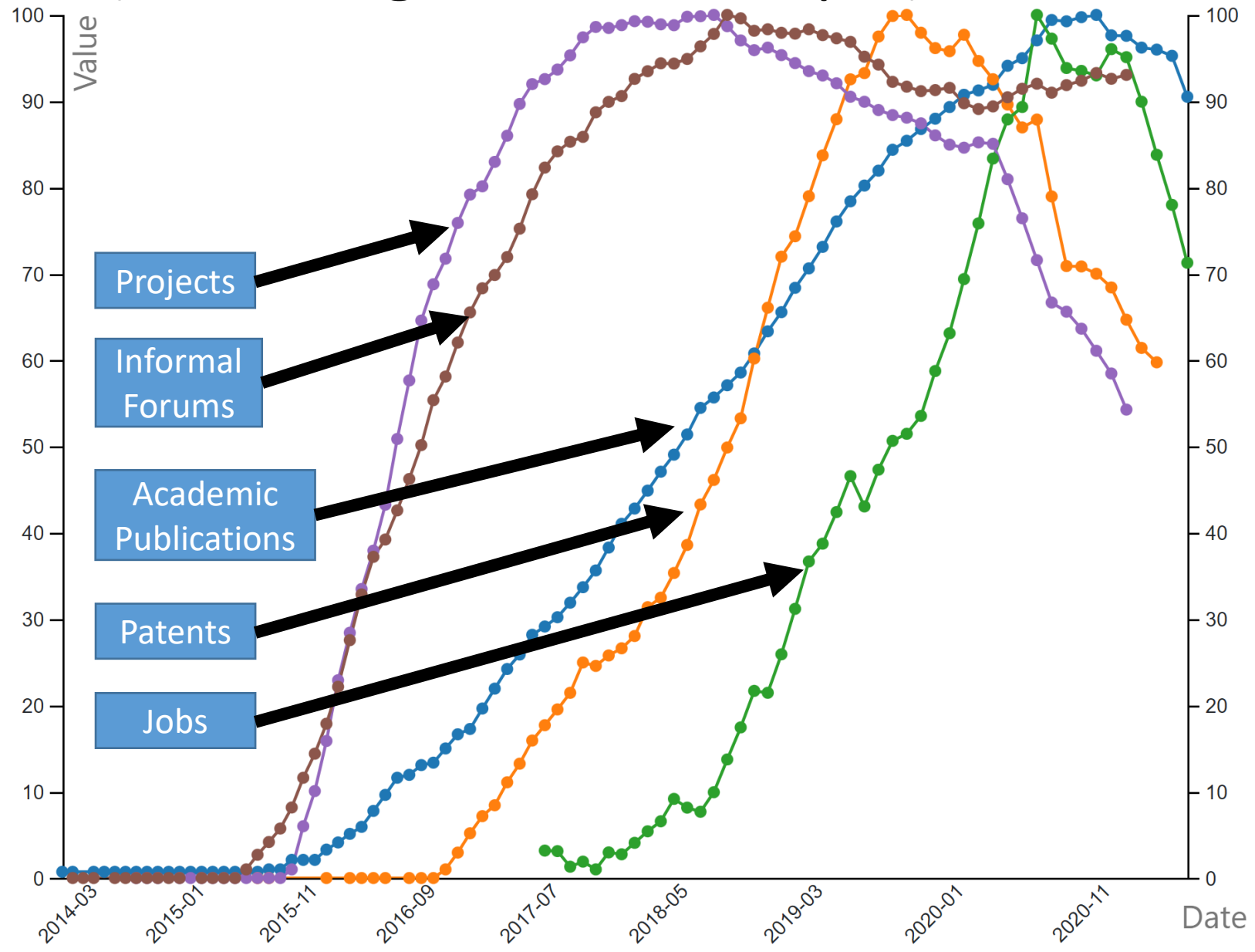
# Cascading influence of an innovation ("tensorflow" example)

- Impact of an innovation to the ecosystem
- Example for “**Google TensorFlow**” used by all of us many times per day
- Cascading influence:
  - Starting with **media**,
  - ...triggering **projects**,
  - ...resulting in **academic publications**,
  - ...followed by **patents**,
  - ...influencing **job market**

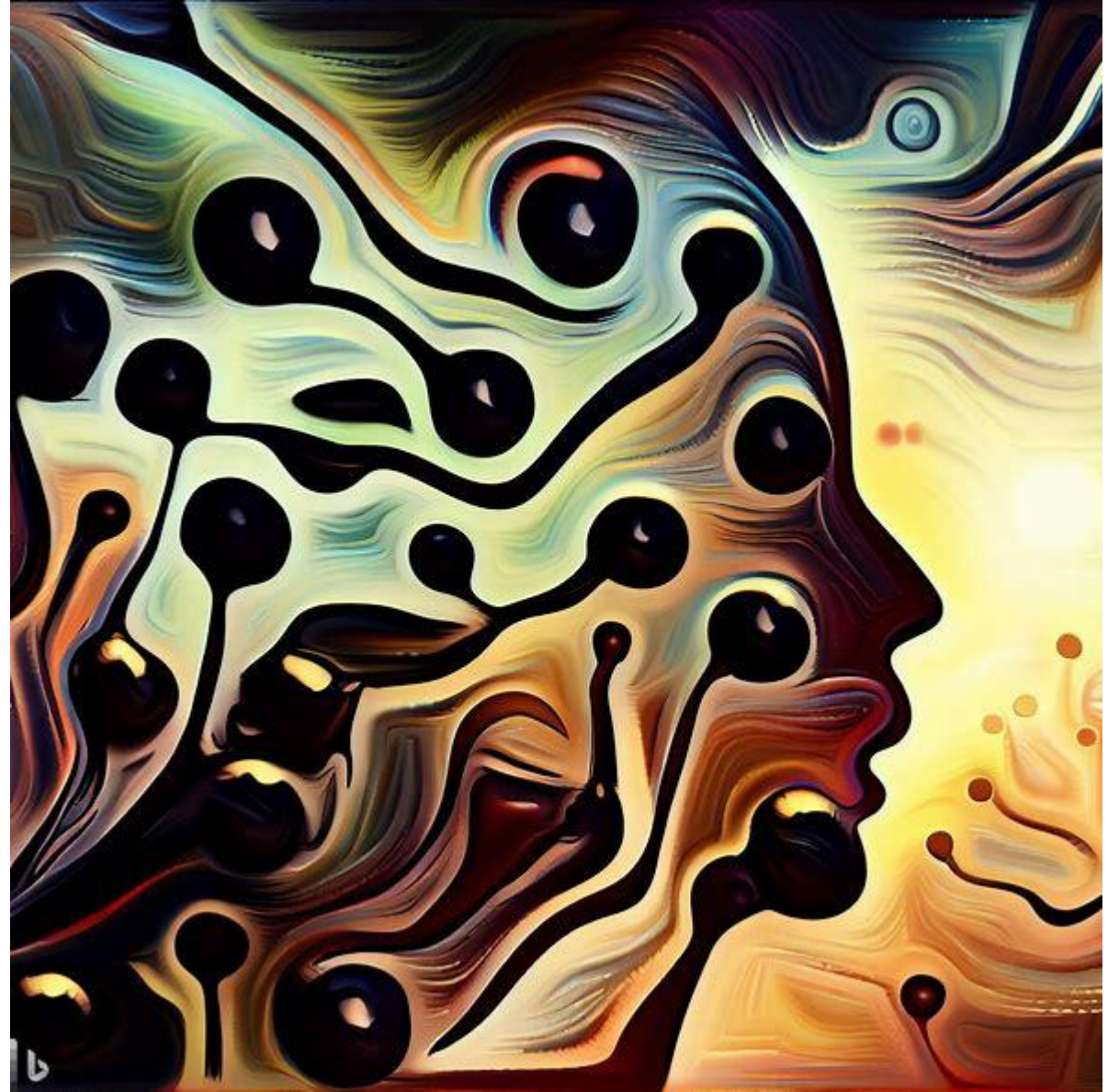




# Cascading influence of an innovation ("LSTM algorithm" example)



Questions?



# Google Astra Agent

- Integrating audio, video, text understanding in real-time
- <https://www.youtube.com/watch?v=nXVvvRhiGjl>

