Class 8

NEW GENERATION OF INNOVATION SYSTEMS

Glauco Arbix

Class 8 – USP – Pós 2023

INTRIGUING QUESTIONS

- Why do some countries catch up while others fall behind?
- Under what circumstances and how can latecomer countries forge ahead and, eventually, become a developed country?

- WW II + Cold War + economic boom driven by a wave of innovations indicated that S&T were critical to geopolitics and well-being
- Most different governments began to prepare their countries and pushed the formation of ST&I systems in advanced and developing countries

The Dawn of Modern Innovation Systems

- In the post-war period, the US developed the world's most effective innovation network, through a set of institutions, new labs, policies, corporate R&D and heavy government investment, most of it focused on maintaining a technological and military advantage over the Soviet Union
- Countries like the UK, France, Italy, the Nordics and even Germany, Japan and the entire bloc led by the Soviet Union sought to articulate universities, research centers, companies and government, although not always with the same characteristics

The birth of the concept of National Innovation System

The first explicit use of the concept appears in Christopher Freeman's book on Japan. The concept refers both to the nation- specific organization of subsystems and to the interaction between subsystems

Freeman defined it as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies."

Christopher Freeman, *Technology and Economic Performance: Lessons from Japan* (London: Pinter, 1987)

S&T in the U.S.

- **Unlike most countries, the US does not have a nationally coordinated system. But because of heavy federal investment, primarily in the defense industry, many analysts point out that the US has a "hidden development state"**
- **"The emergence of triadic interactions […] among university-industry-government in the transition from an industrial to a knowledge economy may be seen as a conscious innovative stream rather than a chance evolutionary event." Etzkowitz**

Nelson, Richard (ed., 1993). National Innovation Systems. A Comparative Analysis. NY: Oxford Un. Press
Mazzucato, Mariana (2015). The Entrepreneurial State: Debunking Public vs. Private Sector Myths. PublicAffairs

- Infrastructure
- Investment
- Regulatory framework
- Friendly environment
- Qualified people

Starting with the basics:
Triple Helix to Support Innovation

It is necessary to go further

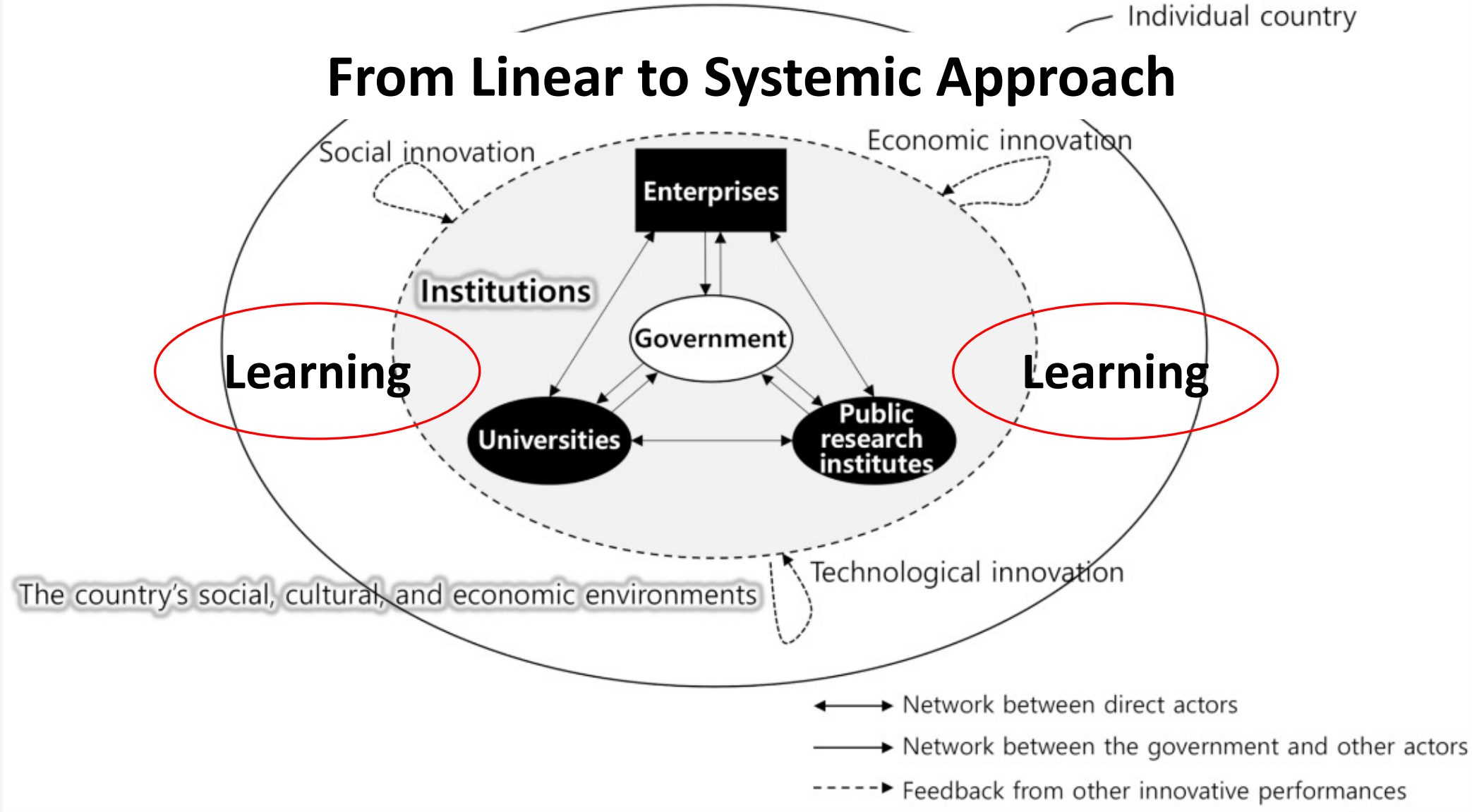
Government is Key

- Triple helix model spread around the world, boosted R&D, the construction of S&T parks, and hubs such as Silicon Valley and Boston's Route 128
- The weight of the State cannot be neglected
- “Independent of their size, government programs can play a critical role in supporting the formation of startups and small businesses.” (Keller & Block)

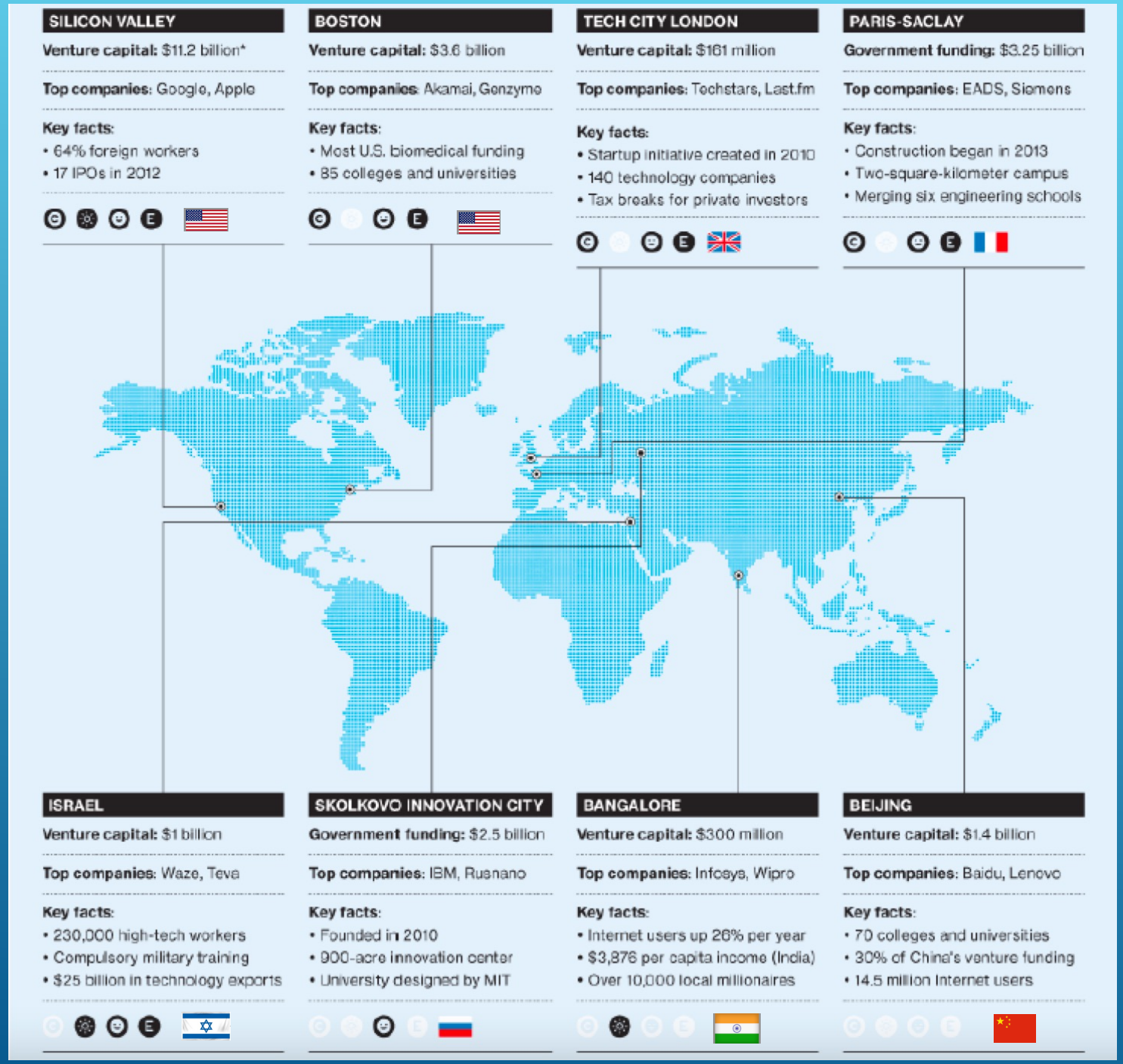
- Matthew R. Keller, Fred Block, Explaining the transformation in the US innovation system: the impact of a small government program, *Socio-Economic Review*, V. 11, Issue 4, Oct 2013
- Alic, John (2007).Trillions for Military Technology. How the Pentagon innovates and why it Costs so Much. NY: Palgrave Macmillan

Figure 1. The framework of a national innovation system.

From Linear to Systemic Approach



Top Innovation Clusters in the World



KEY

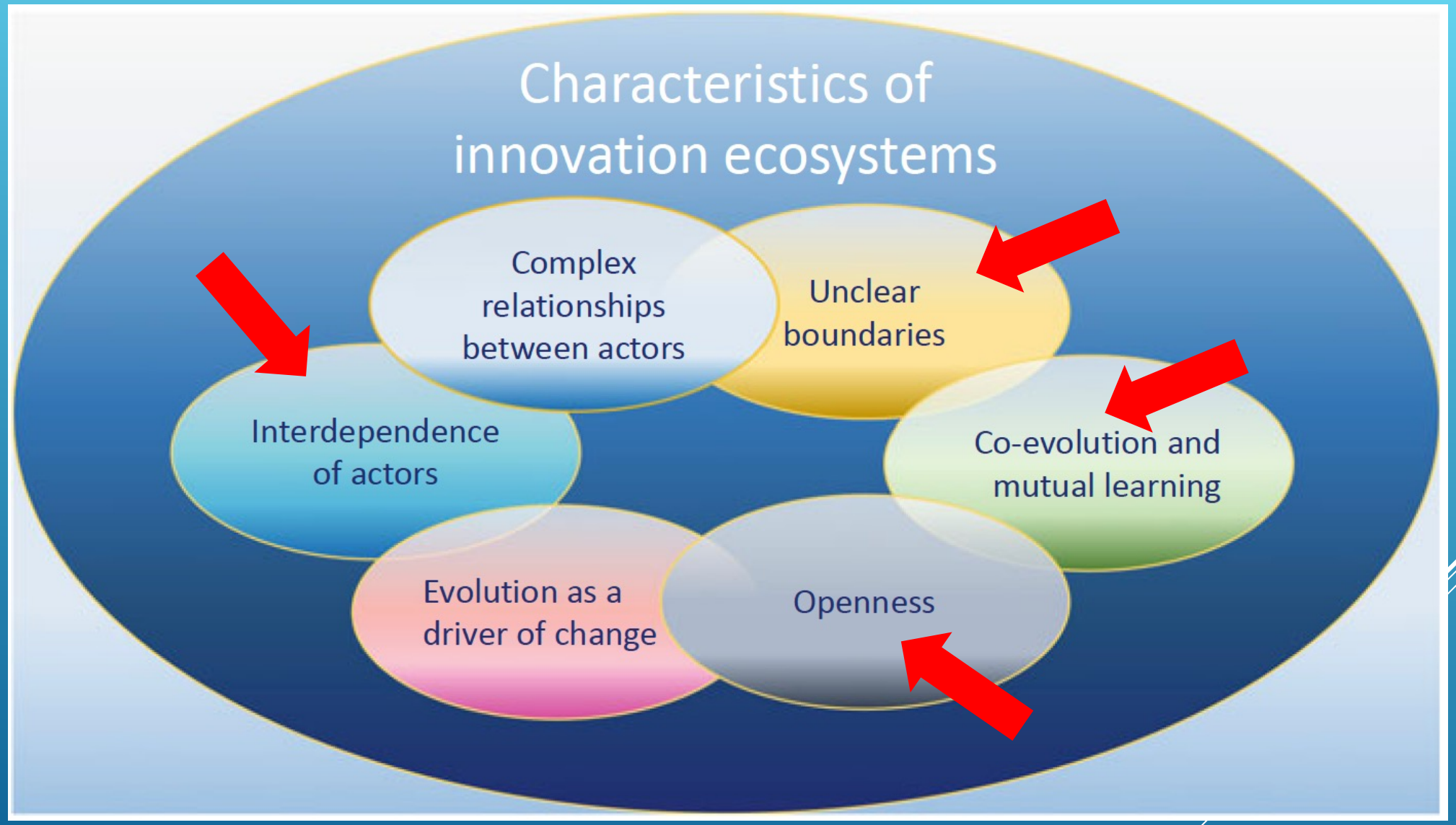
- STRONG IP PROTECTION
- GOOD WEATHER
- LIBERAL IMMIGRATION LAWS
- ENTREPRENEURIAL CULTURE

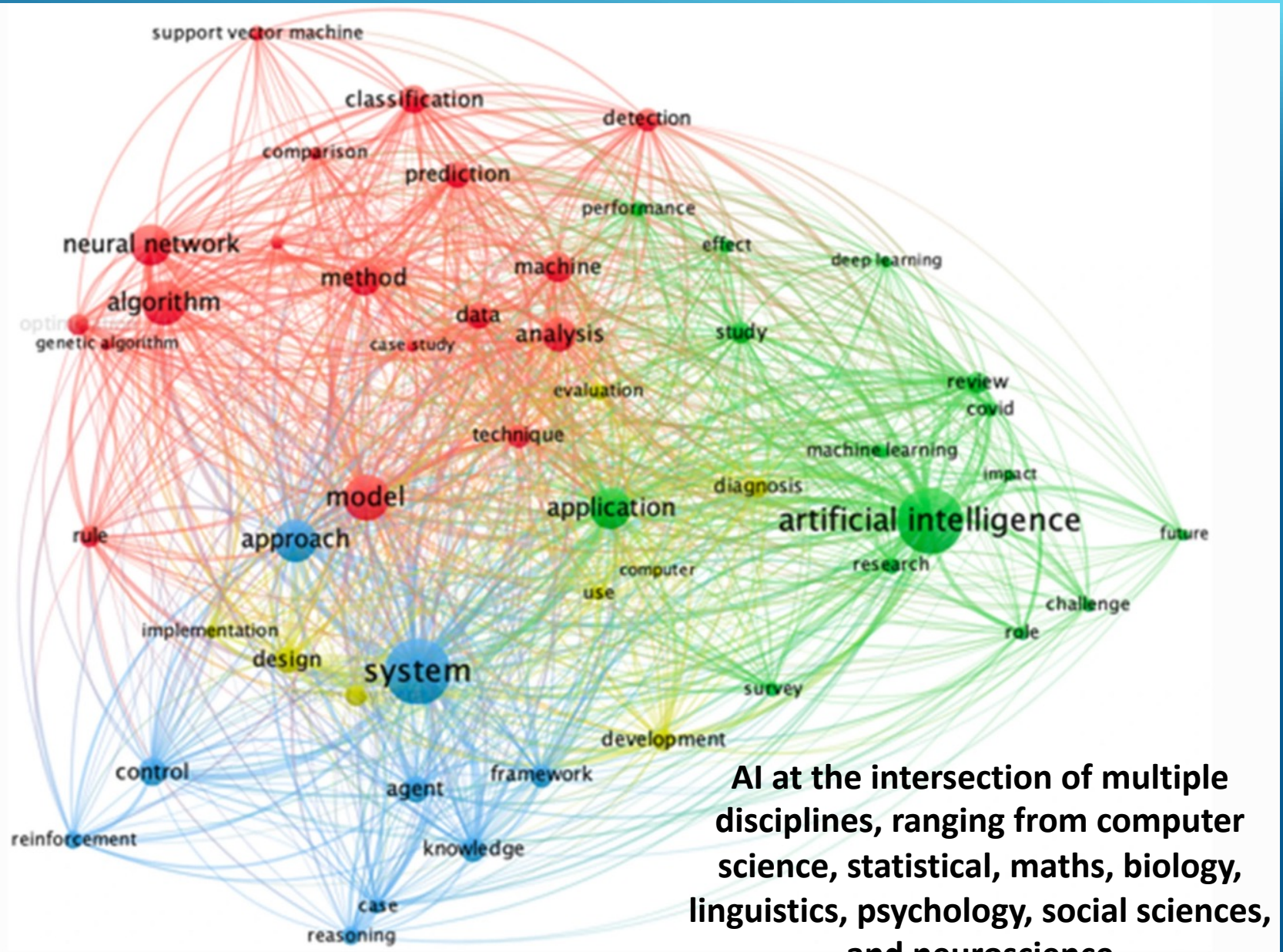
Source: Nader Sabry, 2021

New technology cycle

Systems are reaching a new level of complexity and interdependency between traditionally separate fields of knowledge.

Technology fusion requires the interaction between different actors and pushes ecosystems to work in networks (instead of chains).


Characteristics of innovation ecosystems
Complex relationships between actors
Unclear boundaries
Interdependence of actors
Co-evolution and mutual learning
Evolution as a driver of change
Openness



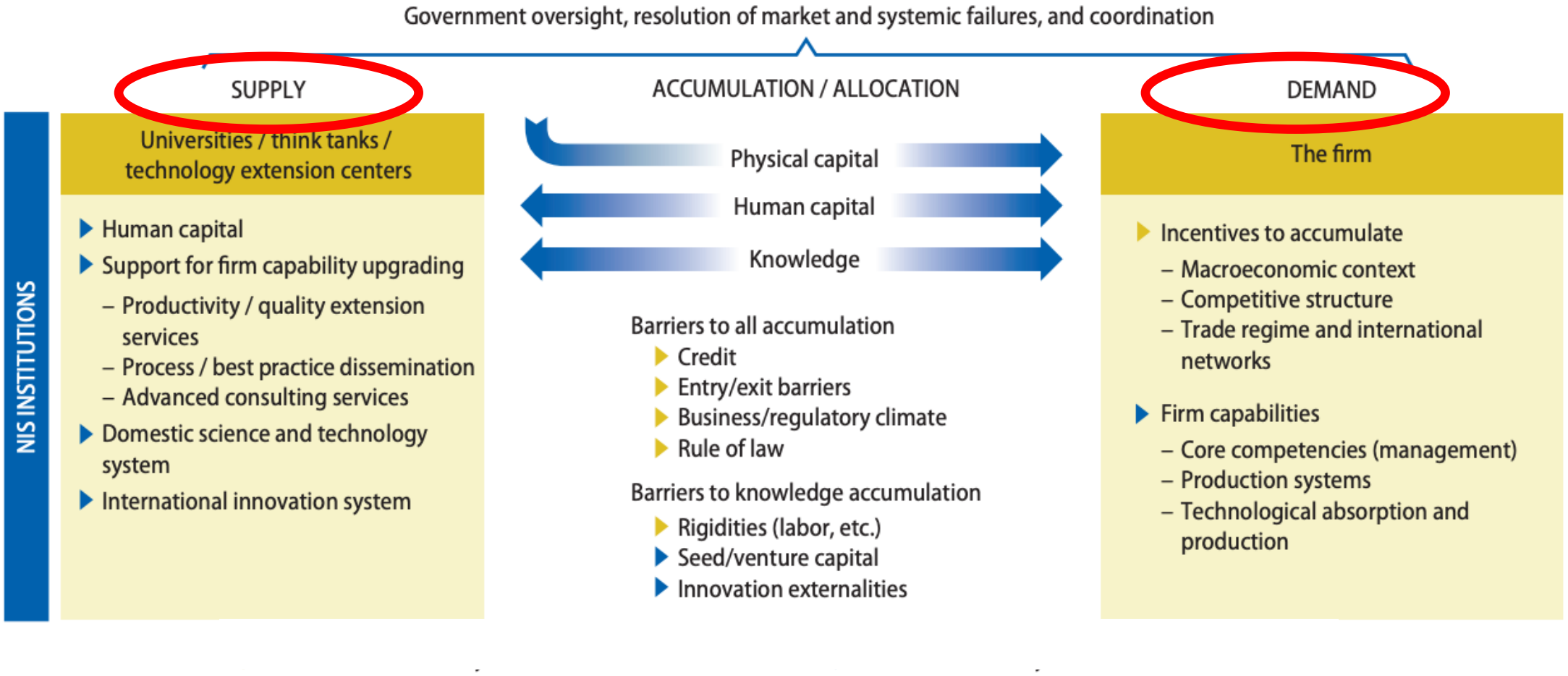
Semantic network of artificial intelligence

AI at the intersection of multiple disciplines, ranging from computer science, statistical, maths, biology, linguistics, psychology, social sciences, and neuroscience

AI as GPT is a knowledge field and the invention of a method of invention

Cockburn, Iain, Rebecca Henderson & Scott Stern. The Impact of AI on Innovation. NBER, Working Paper 24449, March 2018

A New Generation of NISs is Under Construction



Source: Cicera and Maloney 2017.
Note: NIS = national innovation system.

Based on the Koren experiments

AI enablement

Foundation for AI mostly linked to data processing/data pipeline, although not AI itself

- Hardware infrastructure for data production, collection and storage (chip, sensors, servers, data-centers, …)
- Computing tools for calculation and data management (MDM, distributed computing, …)

AI production

AI development environment where AI applications are created based on AI enablement elements

- AI algos, from small pieces of algorithm to self-standing solutions available in AI libraries
- AI visualization tools to display results of AI solutions and interact with users
- AI platforms and AI code's languages and protocols to build applications

AI consumption

Usage and diffusion of AI

- Leverage of one or multiple AI products to form a ready-to-use AI solution
- Packaging of AI solutions into commercial offers
- Transformation of companies to enable successful interface with enablement and production blocks (Change management with end-users , adaptation of processes and infrastructures, …)

Effectiveness depends on balanced combination of three capacities

1

- Creation. Diffusion, Absorption, Utilization

2

- Role of governments change to be facilitators of cooperation

3

- Entrepreneurship
- Competition rules
- Labor market conditions
- Human capital

AI systems are dominated by few countries and few tech giants

- Governments have played a decisive role in supporting corporations and directing research in AI
- More recently, the US and China as well as the European Commission have become major actors in a global race for AI dominance.

The combined corporate and state interest in directing AI is shaping the world's future

To what degree can the rest of the world influence the direction of technological change?

Liu, X., Wang, X., & Hu, Y. (2021). Catch-up and radical innovation in Chinese state-owned enterprises: Exploring large infrastructure projects. Edward Elgar
Rikap, Cecilia and Bengt-Åke Lundvall (2022).The Digital Innovation Race. Conceptualizing the Emerging New World Order. Palgrave Macmillan

- After the war, Japan invested in domestic knowledge and learned from through reverse engineering, without opening up for foreign investments
- China has followed a different strategy by opening for FDI in the 1980s, aiming to learn from foreign firms
- Government used foreign firms' desire to access China's domestic market and low wages to negotiate access to their knowledge through joint ventures

The success of this strategy was mixed. For a long period, high growth rates were based on low wages and high rates of capital accumulation rather than on technical progress.

Winds of change

- With the 2006–2020 Plan for the Development of S&T, the term indigenous innovation became the keyword
- A crucial ambition of this plan was to overcome the dependence of foreign firms in advanced technologies
- This new direction towards indigenous innovation was confirmed in the Made in China 2025
- In two decades, graduates from Chinese universities grew tenfold, reaching 7 million students in 2017, more than doubling US figures. R&D expenditure has now reached the level of the European Union (2.2%). And China created its own multinationals.

- NSF data shows that China's share of the world's R&D intensive industries grew from 6% in 2003 to 21% by 2020.
- Chinese firms are now frontrunners in high-speed trains, wind turbines, supercomputers, space launch vehicles, satellites and liquid crystal displays. And AI
- AI-related policies also include the Digital Silk Road, a new internet traffic route from China to Europe exclusively managed and supervised by the Chinese and announced in 2015 as part of the Belt and Road Initiative.

Protection and synergy with big techs

- The rapid advance of AI came with the the decision to create the China's Great Firewall, an ensemble of social media regulations, IP blacklists, keyword filters, data gateways and human censors
- The Firewall limited the access for foreign companies to internet-based business (including cloud services), which favored local companies, in particular Baidu, Alibaba and Tencent
- The Great Wall enabled Chinese tech giants to harvest enormous volumes of data, a prerequisite for establishing China as world leaders in AI applications.

Selected Tech Giants' publications and Patents Co-authorships and Co-ownerships

Company	*Publications (until 2019 included)*	*Co-authoring organizations*	*Applied and granted patents (until 2017 included)*	*Co-owned patents with other organizations*
Amazon	824	766	10,063	13 (0.1%)
Microsoft	17,405	4025	76,109	160 (0.2%)
Google	6447	3397	25,538	65 (0.3%)
Tencent	643	366	5462	13 (0.2%)
Alibaba	685	427	3532	0 (0%)

Source: Web of Science, USPTO, WIPO European, Japan, Australian, British, Canadian, French, German, Russian and Korean patent offices. Rikap and Lundvall, 2022

Two decades after the introduction of the great firewall, Alibaba and Tencent are digital forerunners

Chinese tech giants rely on the R&D capabilities of Chinese universities and public research organizations. But also, on privileged access to the Chinese market for digital services and data, facilitated by government

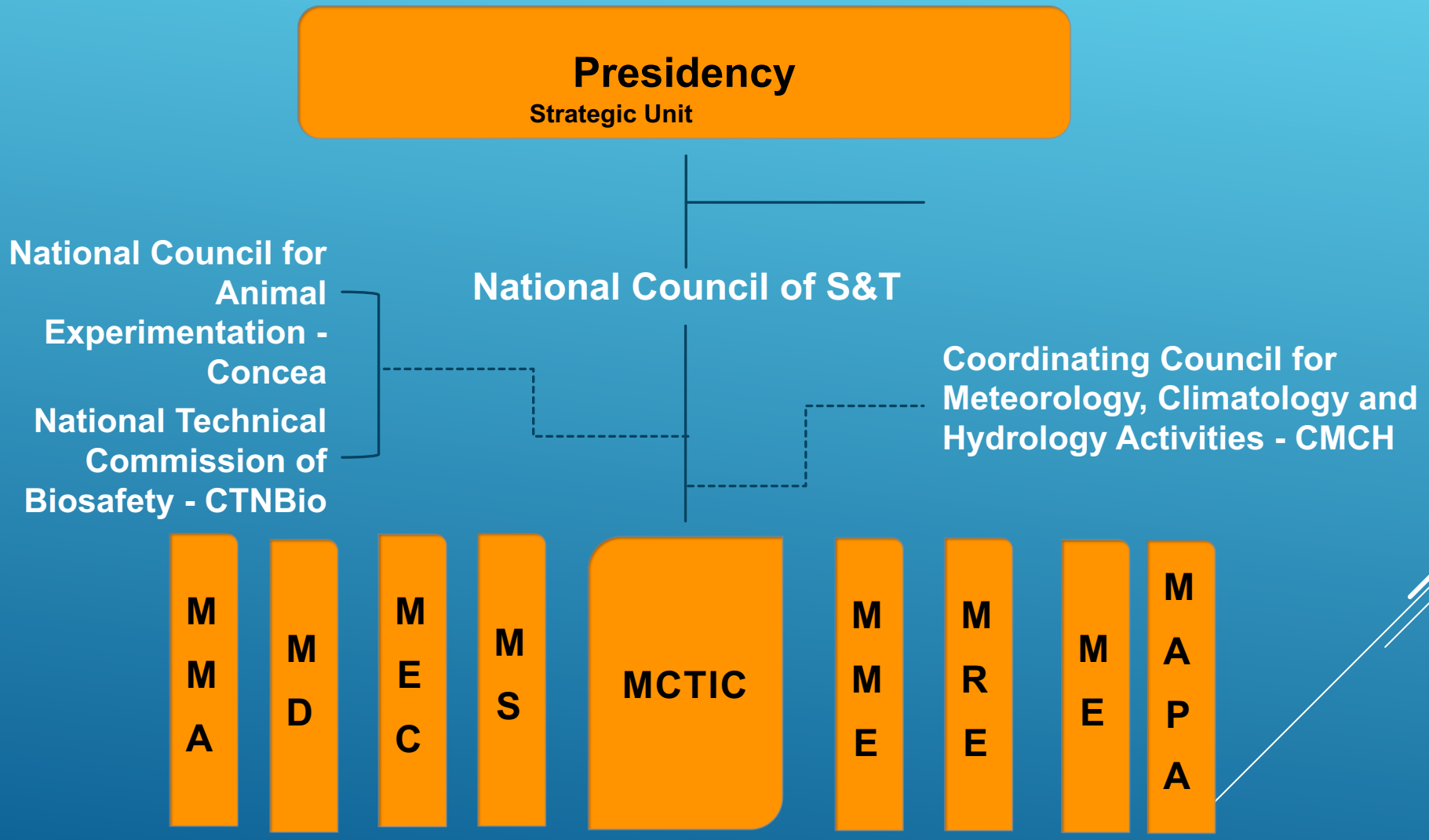
- China’s AI success is an example of how, under specific political and economic circumstances, a transformative technology opened a window of opportunity for technological catching-up
- But there is no linear evolution. To become a world leader, China must build capabilities in the design and production of advanced chips and strengthen its AI basic research.
- Will China succeed to become the world leader in AI in 2030?

1. Despite the decisive weight of the NIS, the Chinese state laid the foundation for AI and for their tech giants through measures that went far beyond technology and innovation
2. Although the competition between the US and China can generate advances, the way in which technological development is taking place, based on interests of few states and few corporations, increases inequalities between countries.
3. If DCs can't generate AI technologies, they will just be users, reinforcing tech giants' current dominance, and the tendency of knowledge extraction by lead countries
4. AI has the potential to create wealth and contribute to tackling global challenges, such as poverty and ecological disasters

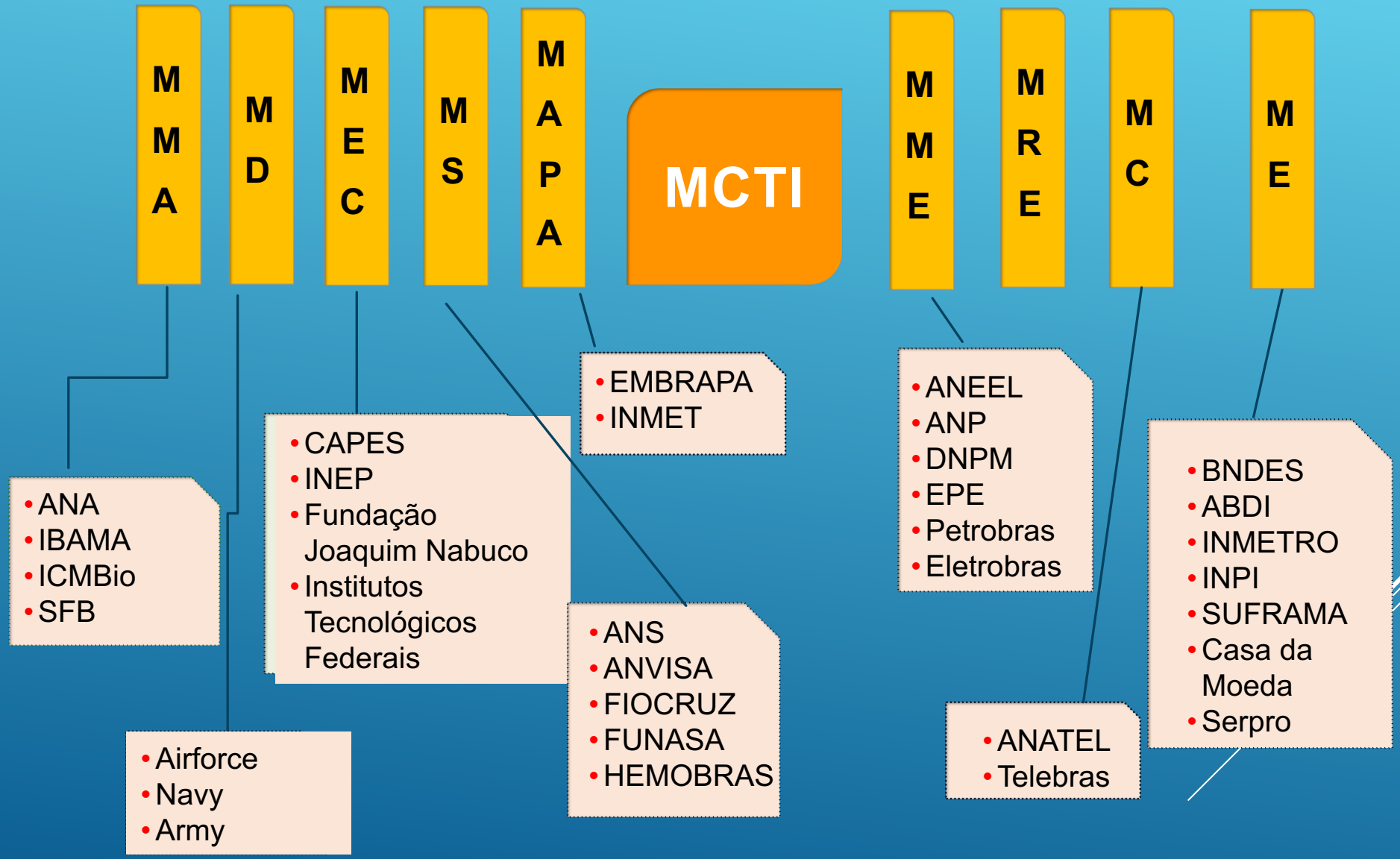
- But the current pattern of development, where the trajectory of AI is dependent on the national interests of developed countries and exploited in the interests of a handful of giant corporations, opens a huge gap between what could be achieved with AI and what is actually achieved.
- It will be necessary a new legal framework to regulate big techs, new ways of governance, and more ambitious forms of international cooperation.


Brazil

Brazilian NIS



Brazil: Ministries and Supervised Departments

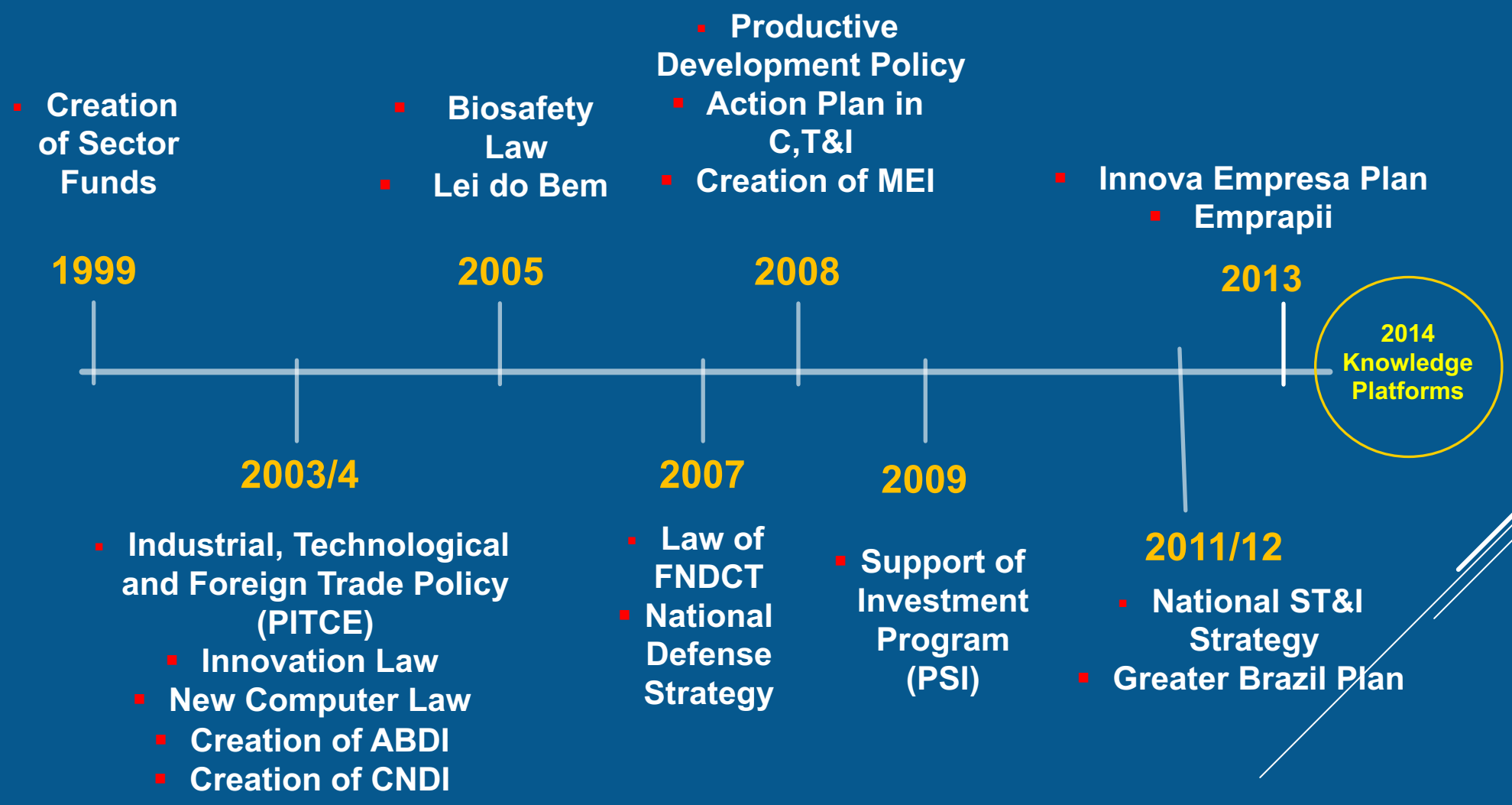


MCTI

- Unidades de Pesquisa: INPA, INPE, LNCC, CTI, CEITEC, CNPEM, IDSM, IMPA, RNP, CGEE, IEN...

- FINEP
- CNPq
- EMBRAPII
- AEB

Brazil: Evolution of the Legal and Institutional Framework



Source: Arbix, 2019

1950-2010: Industrial Policies in Brazil

Period	1950-1980	1990-1999	2002-2012
Context	▪ Import substitution ▪ State leadership ▪ Protectionism ▪ Authoritarian regime ▪ Restricted democracy	▪ Privatization and Liberalization ▪ Regulatory state ▪ More open economy ▪ Democratic regime ▪ No industrial policy	▪ Stability and reduction of inequalities ▪ Economic growth ▪ Regulatory and Inducing state
Focus	▪ Industrialization	▪ Efficiency and quality	▪ Focus on Innovation
Vision on Technology and Innovation	▪ Industrialization would create internal demand and provoke competition, capable of generating technology and increasing competitiveness ▪ Technology is a by-product of growth	▪ Competition and economic openness generate more innovative companies ▪ Technology is a by-product of growth	▪ In general, technology continues to be seen as a by-product of growth, despite a few policies aimed at stimulating R&D in companies

Fonte: Arbix, 2019

Industrial and innovation policies (2004-2014)

- 2004: Industrial, Technological and Foreign Trade Policy (PITCE)
- 2008: Productive Development Policy (PDP)
- 2011: Greater Brazil Plan
- 2012: National ST&I Strategy
- 2013: Inova Plan


Thank you