

Techno-economic paradigms

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Degrees of technical change

- Incremental innovation
- Radical innovation
- Changes in technological trajectory
 - Dominant design
- Architectural innovation
- Disruptive innovation
- Changes in the technological system
 - Constellations of technological innovations
- Transitions in the socio-technical regime
 - Technological, economic, social and political alliances
- Changes in techno-economic paradigm
 - New key factor in the economy, with pervasive impact, rapidly decreasing cost and increasing supply

The History of

INNOVATION CYCLES

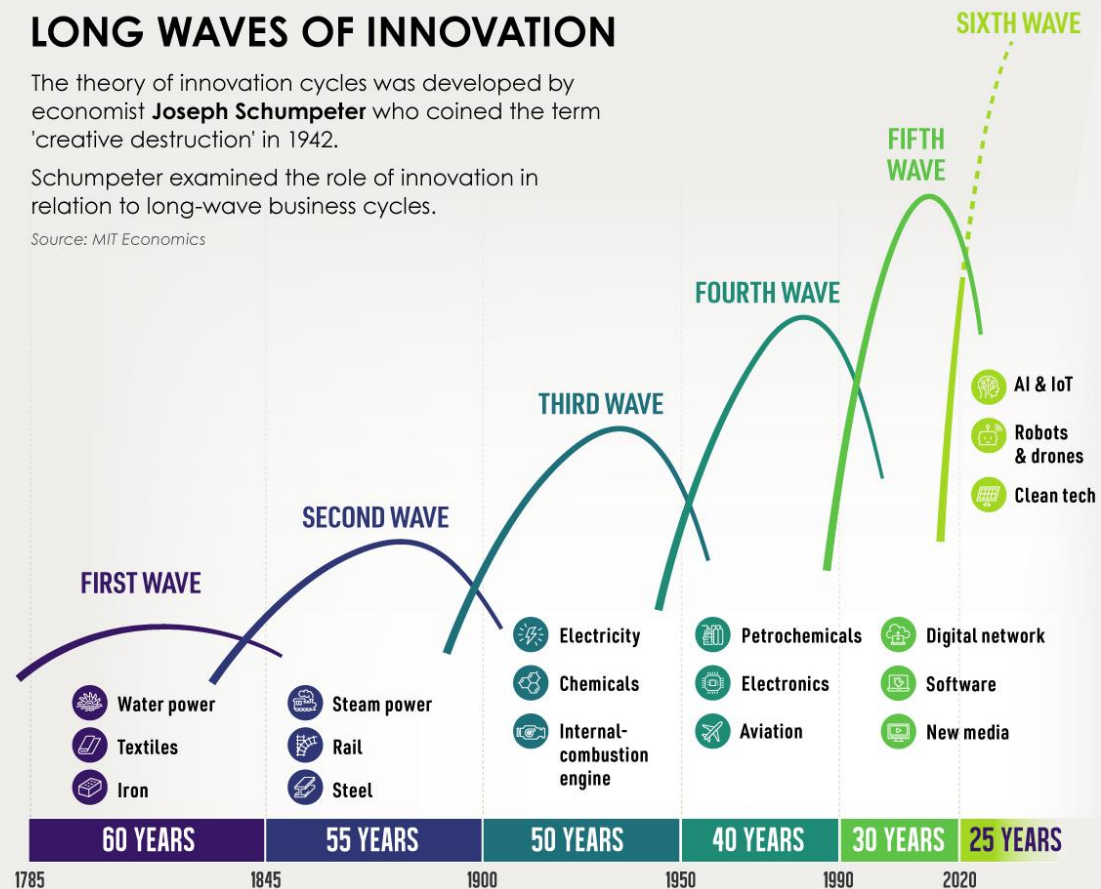
Below, we show waves of innovation across 250 years, from the Industrial Revolution to sustainable technology.

LONG WAVES OF INNOVATION

The theory of innovation cycles was developed by economist **Joseph Schumpeter** who coined the term 'creative destruction' in 1942.

Schumpeter examined the role of innovation in relation to long-wave business cycles.

Source: MIT Economics



Source: Edelson Institute

KEY BREAKTHROUGHS

FIRST WAVE

During the Industrial Revolution, the first factory emerged—a cotton mill in Britain.



SECOND WAVE

As railways proliferated, their networks strongly influenced urban growth.

Source: Nacima Baron, HAL

THIRD WAVE

Henry Ford's Model T introduced the assembly line, revolutionizing the automotive industry.



FOURTH WAVE

Aviation gains mass adoption on a global scale, providing a lever to economic integration.

Source: OECD

FIFTH WAVE

In 1990, 2.3M used the internet—by 2016 this reached 3.4B.

Source: World Bank



SIXTH WAVE

As climate challenges intensify, clean tech may reshape business models and consumption patterns.



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COLLABORATORS RESEARCH + WRITING Dorothy Neufeld | ART DIRECTION + DESIGN Joyce Ma

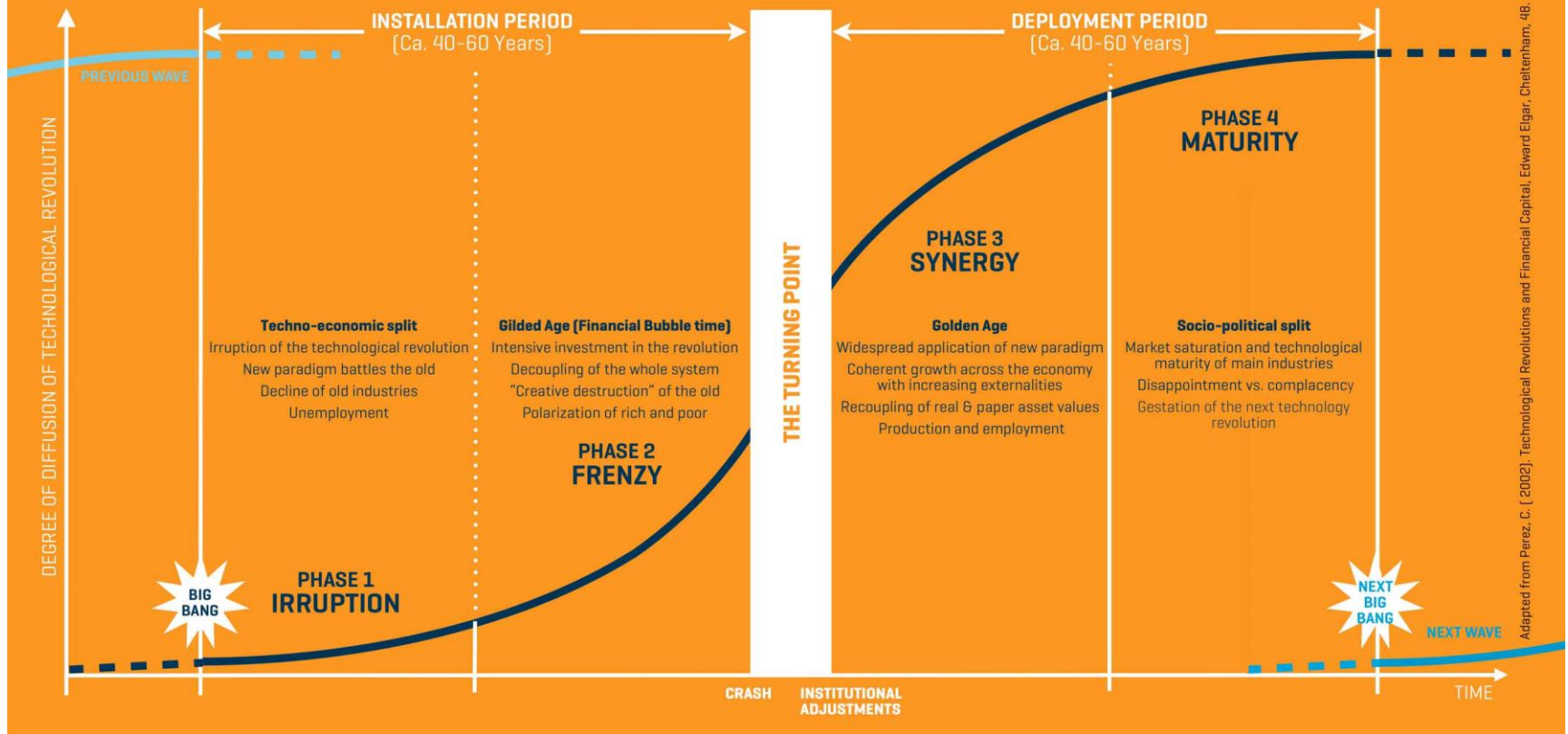
6 κύκλοι με φθίνουσα διάρκεια;

First Wave	Second Wave	Third Wave	Fourth Wave	Fifth Wave	Sixth Wave
Water Power Textiles Iron	Steam Rail Steel	Electricity Chemicals Internal-Combustion Engine	Petrochemicals Electronics Aviation	Digital Network Software New Media	Digitization (AI, IoT, AV, Robots & Drones) Clean Tech
60 years	55 years	50 years	40 years	30 years	25 years

Source: Edelsen Institute, Detlef Reis

THE 4 PHASES OF A LONG WAVE

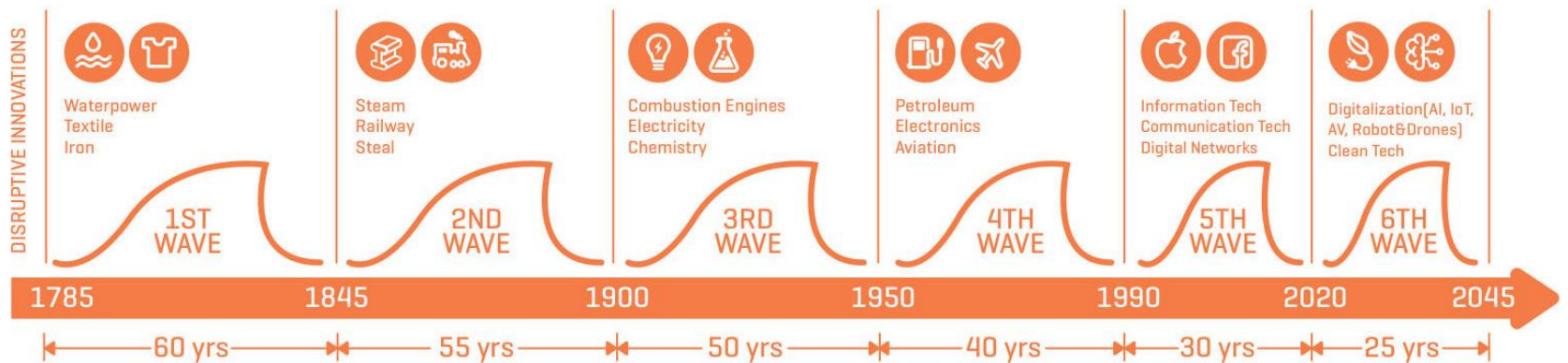
Diffusion of disruptive technologies over a long cycle [Carlota Perez]



<http://www.thinkergy.com/2021/11/04/learn-about-long-waves-to-better-ride-the-next-one-part-1/>

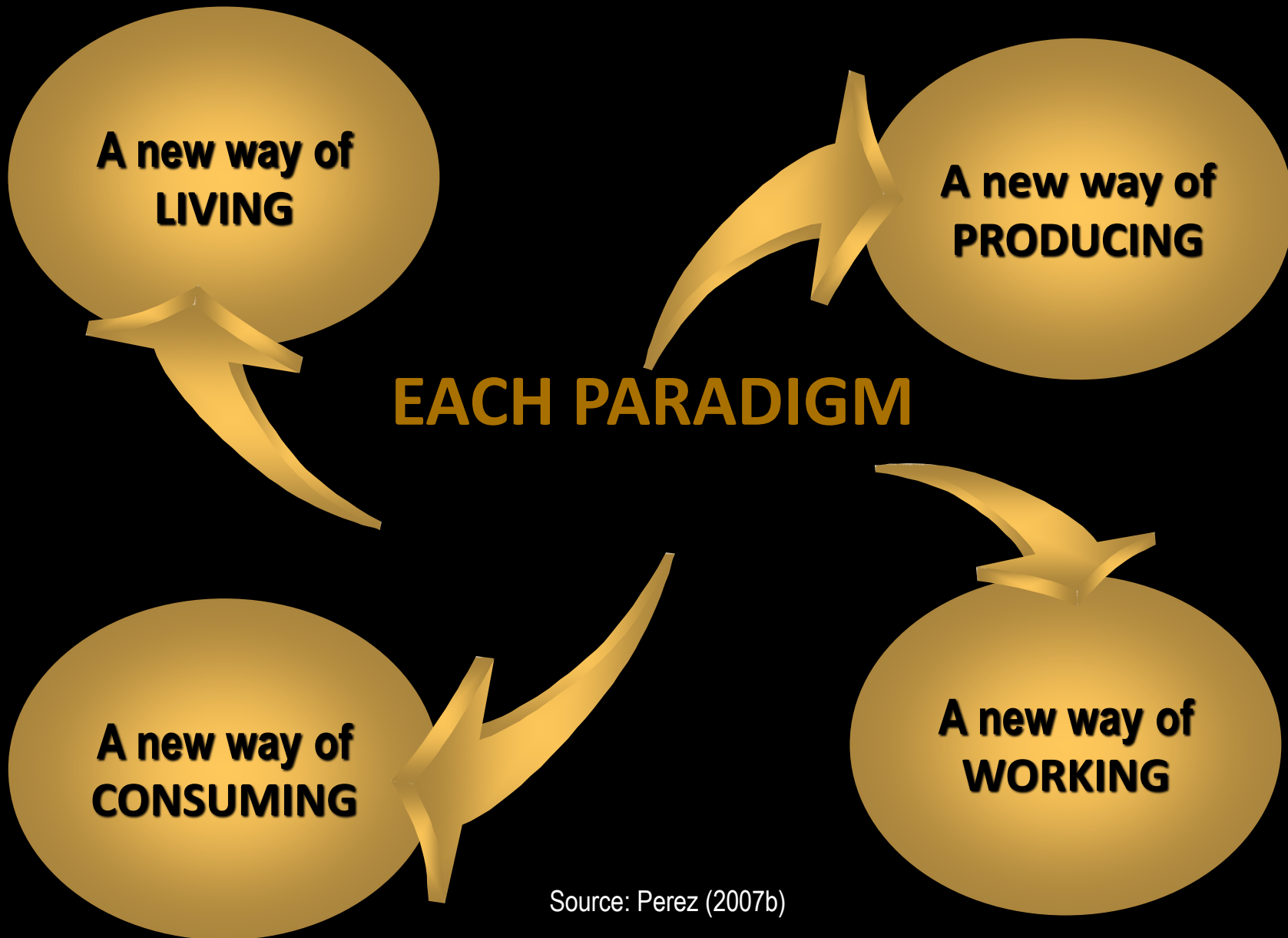
THE CYCLES OF CHANGE

LONG WAVES ACCELERATE



Change of techno-economic paradigm

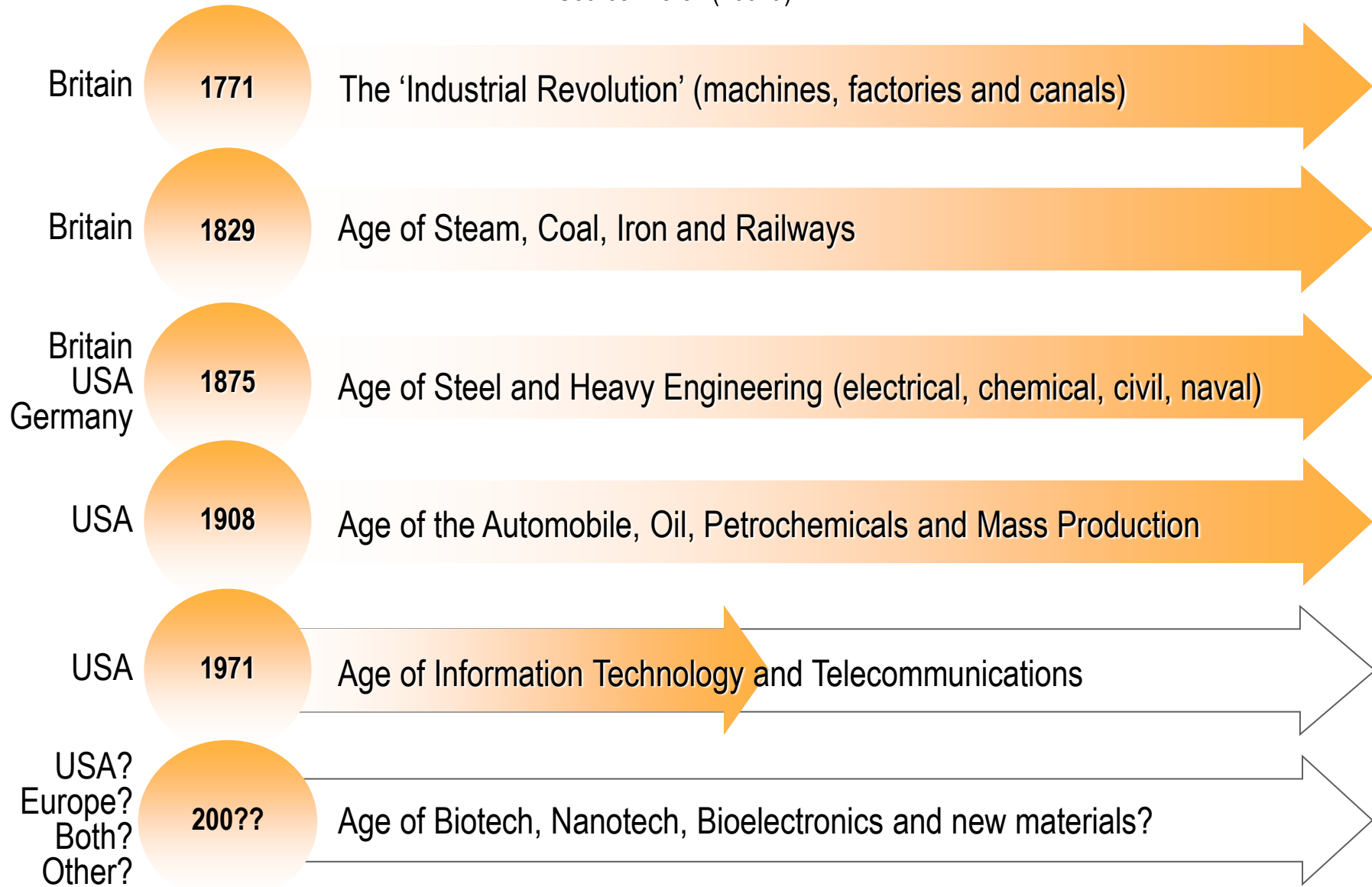
- a new 'best-practice' form of organization in the firm and at the plant level;
- a new skill profile in the labor force, affecting corresponding patterns of income distribution;
- a new product mix in the economy, with shift in investment;
- new trends in both radical and incremental innovation geared to substituting more intensive use of the new key factor(s) for other relatively high-cost elements;
- a new spatial pattern of investment as the change in the relative cost structure transforms advantages;
- a particular wave of intra-structural investment designed to provide appropriate externalities throughout the system and facilitate the use of the new products and processes everywhere;
- a tendency for new innovator-entrepreneur-type small firms also to enter the new rapidly expanding branches of the economy and in some cases to initiate entirely new sectors of production;
- a tendency for large firms to concentrate in those industries where the key factor is produced and most intensively used, (different branches acting as the engines of growth in each successive Kondratiev upswing);
- a new pattern of consumption of goods and services and new types of distribution and consumer



Source: Perez (2007b)

FIVE TECHNOLOGICAL REVOLUTIONS IN 200 YEARS

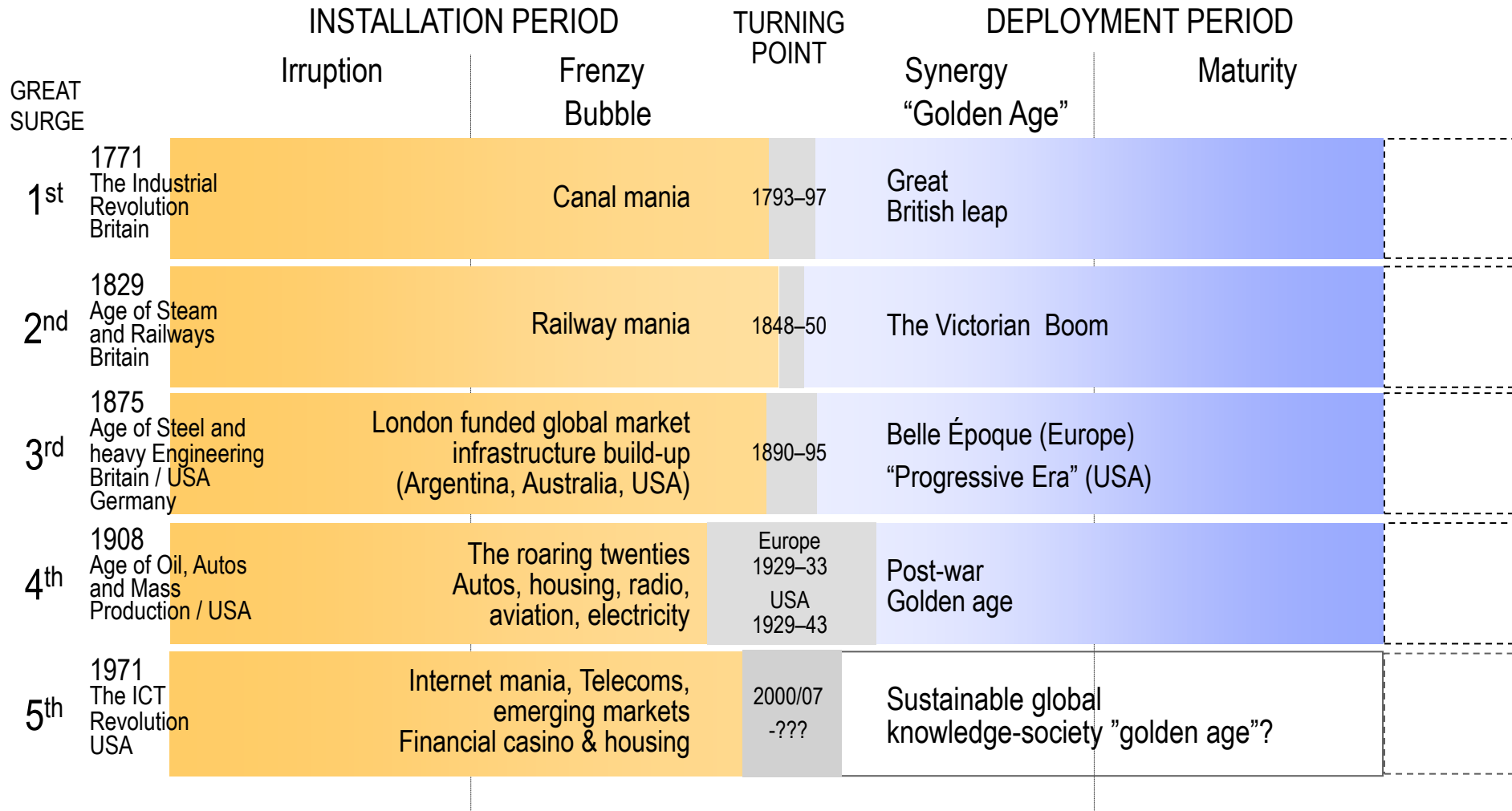
Source: Perez (2007a)



...and takes around half a century to spread across the world

The historical record: bubble prosperities, recessions and golden ages

Source: Perez (2007a)



Source: Perez (2009)

Each Golden Age has been facilitated by enabling regulation and by policies for widening markets and insuring social stability

Some well-known aspects of the paradigm shift taking place since the 1970s



A radical change in best practice 'common sense', though unevenly adopted

Regularities (and uniqueness) emerging from the analysis of successive technological revolutions and their diffusion

Source: Perez (2007a)

REGULARITIES

- A technological revolution every 40 to 60 years, with a financial bubble midway along
- A sequence in phases of 8 to 15 years (with different business and social climates)
- Gradual shift in techno-economic paradigm (TEP) guiding innovation and organisation
- Each paradigm remains dominant for more than half a century (staying beyond its “useful life”)

UNIQUENESS

- Each TEP is fundamentally different and unpredictable
- The forms of adoption are socially, politically and culturally determined
- This leads to geographical and historical variety and continuity (“path dependency”)
- The initiating “core country” has a determining weight in the initial shaping of the TEP

Sharing that “big picture” and its use for analysing the present and gleaning the future is the object of this talk

An interpretation of the present period (and of possible futures)
made on the basis of those recurring historical sequences:

We are now in a period
equivalent (*mutatis mutandi*) to the 1930s and early 1940s,
between the collapse of a “major technology bubble”
and a possible global “Golden Age”

IT IS A “TURNING POINT” IN THE DIRECTION OF THE ECONOMY

A time of instability, tensions, policy confrontations and institutional recomposition

WHEN THE WORLD NEEDS TO DECIDE AMONG ALTERNATIVE PATHS FOR GROWTH
(which this time implies alternative paths for globalisation)

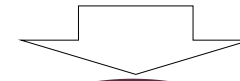
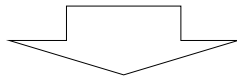
DOUBLE NATURE OF EACH TECHNOLOGICAL REVOLUTION

Radical new technologies

A powerful cluster of new and dynamic technologies, products, industries and infrastructures

New techno-economic paradigm

An interrelated set of generic technologies and organisational principles to upgrade mature industries



Explosive growth and structural change (new engines of growth)



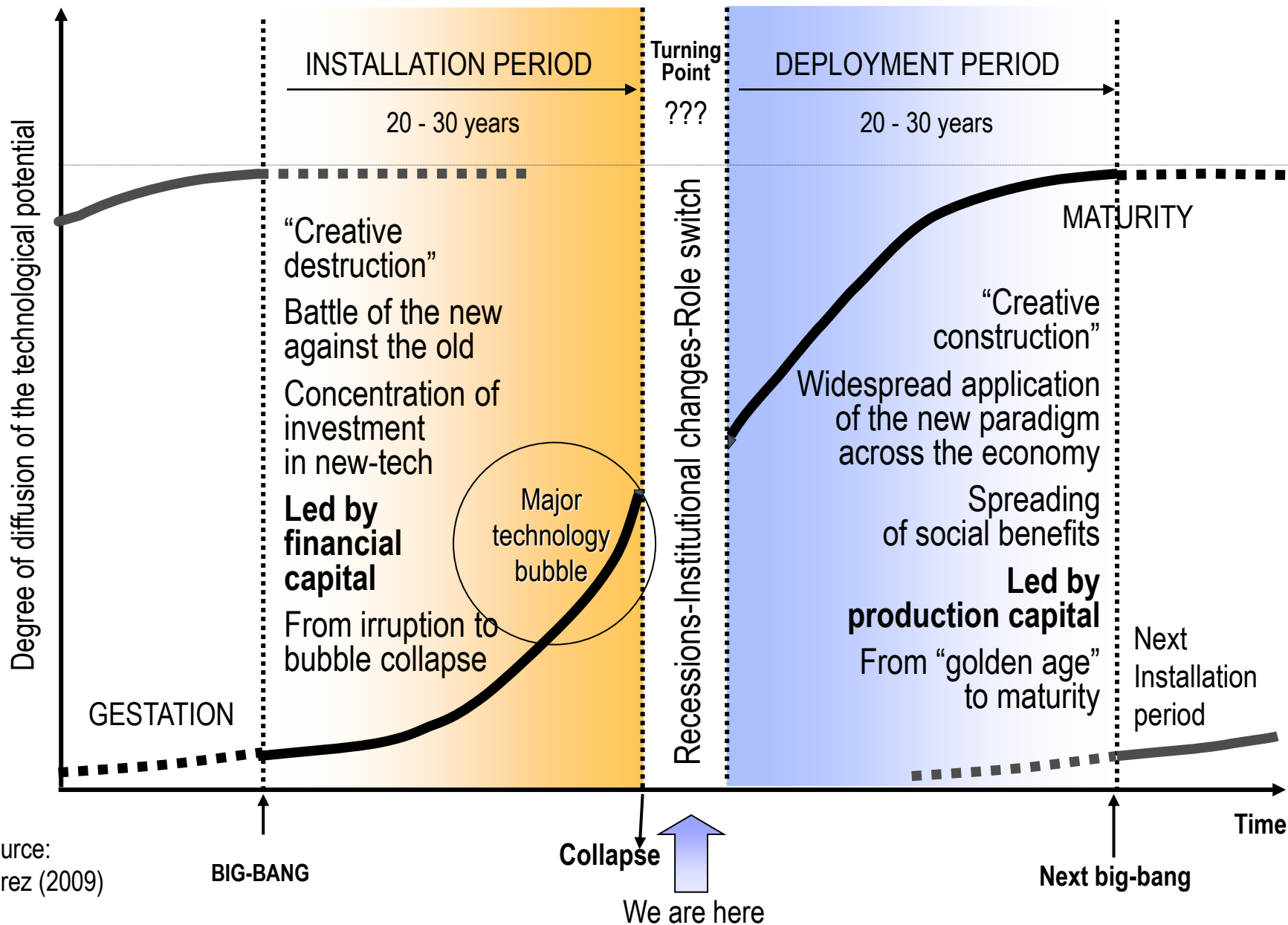
A quantum jump in attainable productivity across sectors

AN ENORMOUS NEW POTENTIAL FOR WEALTH CREATION

...gradually transforming the whole economy as well as society and institutions

Due to the difficulty of social absorption of revolutions and new paradigms

EACH GREAT SURGE IS BROKEN INTO TWO DIFFERENT PERIODS



Source:
Perez (2009)

BIG-BANG

Collapse

We are here

Next big-bang

**Why does financial capital take control in the Installation period?
Why the emphasis on free markets vs. State?**

At maturity of each surge
INCUMBENT PRODUCTION CAPITAL HAS BECOME CONSERVATIVE:

- Tied to fixed capital and to specific knowledge and experience
- With static productivity and saturated markets
- Resisting risk in the new technologies
- Complacent



FINANCIAL CAPITAL BREAKS LOOSE...

- It uses its financial power to back the new technological entrepreneurs
- It forces change across the board against obstacles, resistance and inertia

AND THE STATE MUST BE OUT OF THE WAY

- Financial innovation and extraordinary profits need a *laissez faire* context
- The old institutional framework makes obstacle and must be demolished

**Why does production capital tend to take control after the bubble collapse for the Deployment Period?
Why does it need State support?**

By the time the bubble collapses
INCUMBENT FINANCIAL CAPITAL HAS BECOME AN OBSTACLE:

- Resisting long-term investment
- Demanding short-term gains
- Deviating funds from production into “quasi-gambling”
- Arrogant... and powerful!



PRODUCTION CAPITAL NEEDS AUTONOMY...

- To establish long-term strategies and make long-term investments for expansion
- To form alliances or oligopolies to extend its market reach and reduce survival competition

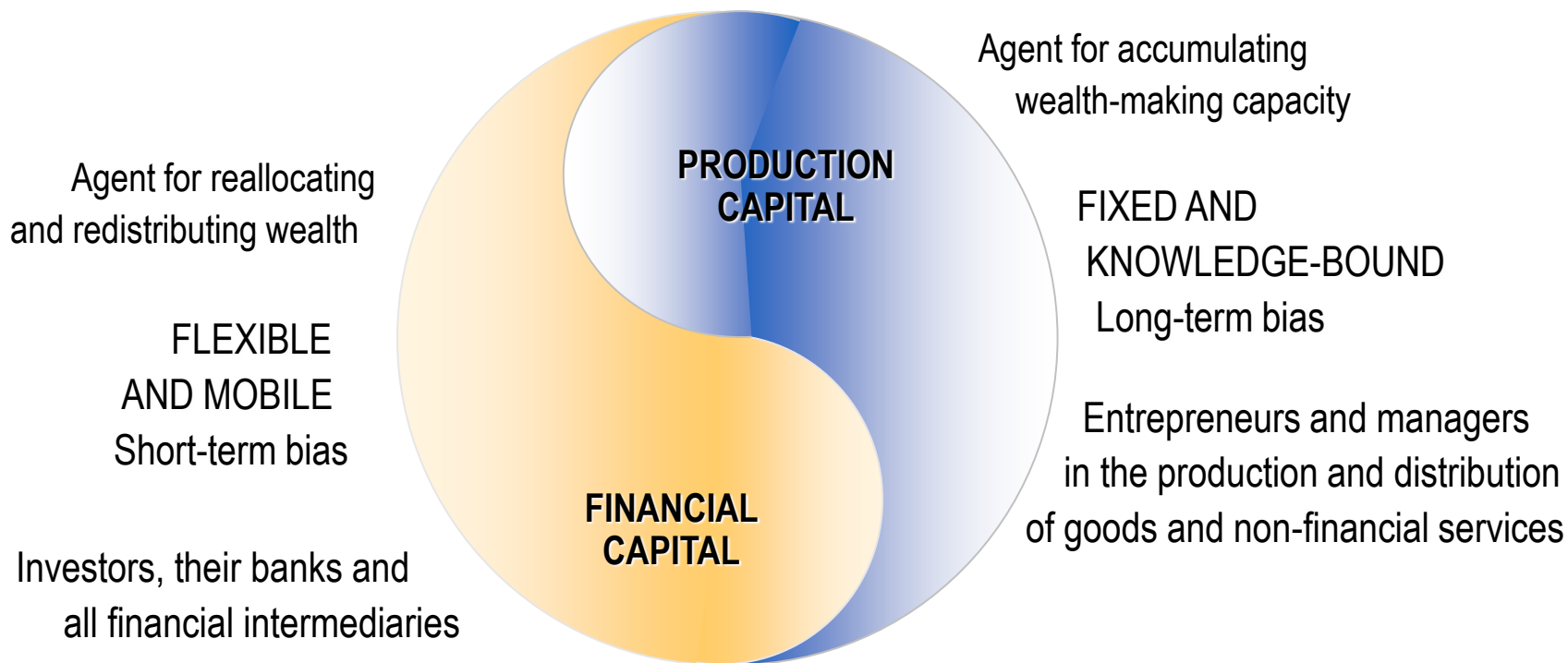
AND THE STATE MUST INTERVENE

To enable the full deployment of the installed paradigm by regulating finance and expanding the appropriate markets (often through direct or indirect income redistribution), etc.

Why the bubble? Why this pattern? Why the role switch?

THE DYNAMICS OF THE CAPITALIST ECONOMY IS SHAPED
BY TWO DIFFERENT AND FUNCTIONALLY SEPARATE PROFIT-SEEKING AGENTS

Source: Perez (2007a)



Financial capital can massively redirect resources and “force” new paradigm diffusion

Production capital is better for carrying growth and expansion within an established TEP

THIS TIME THE MID-SURGE BUBBLE HAPPENED IN TWO STAGES

FIRST

Technological innovation

The INTERNET MANIA
in the 1990s

NASDAQ collapse
in 2000

THEN

Financial innovation

The EASY CREDIT BOOM
in the 2000s

FINANCIAL MELTDOWN
in 2007-08

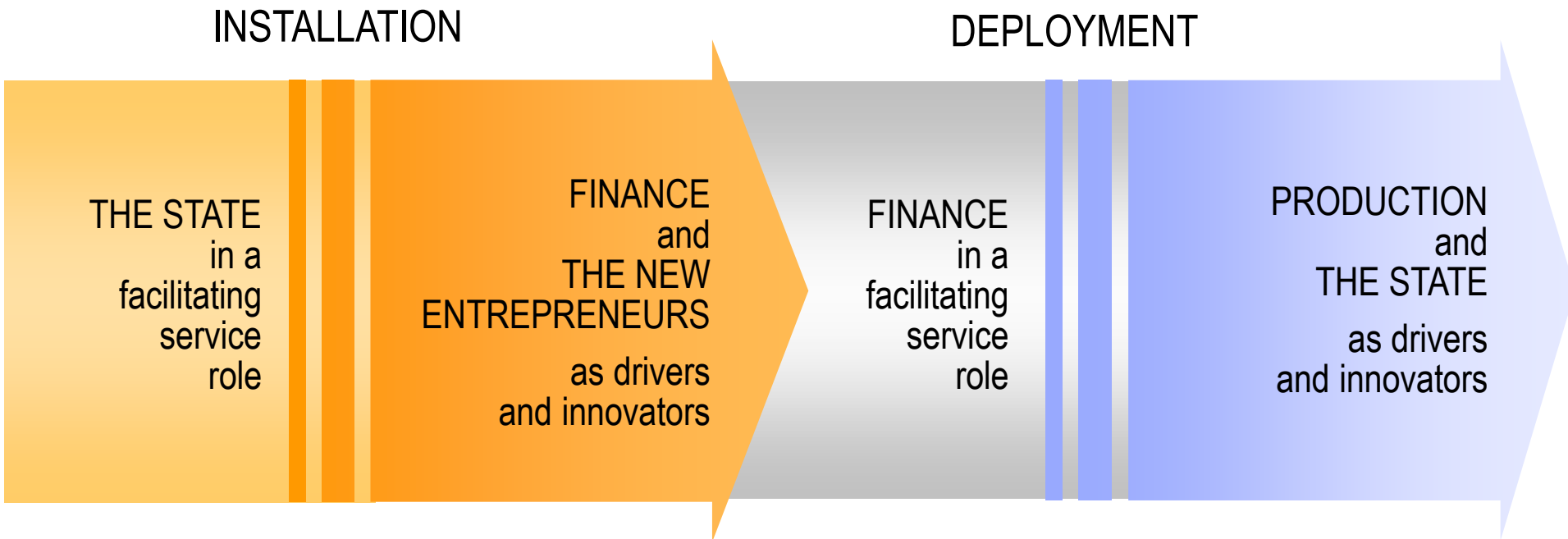
SO WE ARE NOT FACING A MERE FINANCIAL CRISIS
BUT A STRUCTURAL SHIFT

Source: Perez (2009)

Understanding this is crucial
for finding effective solutions to the current crisis

The structural shift involves

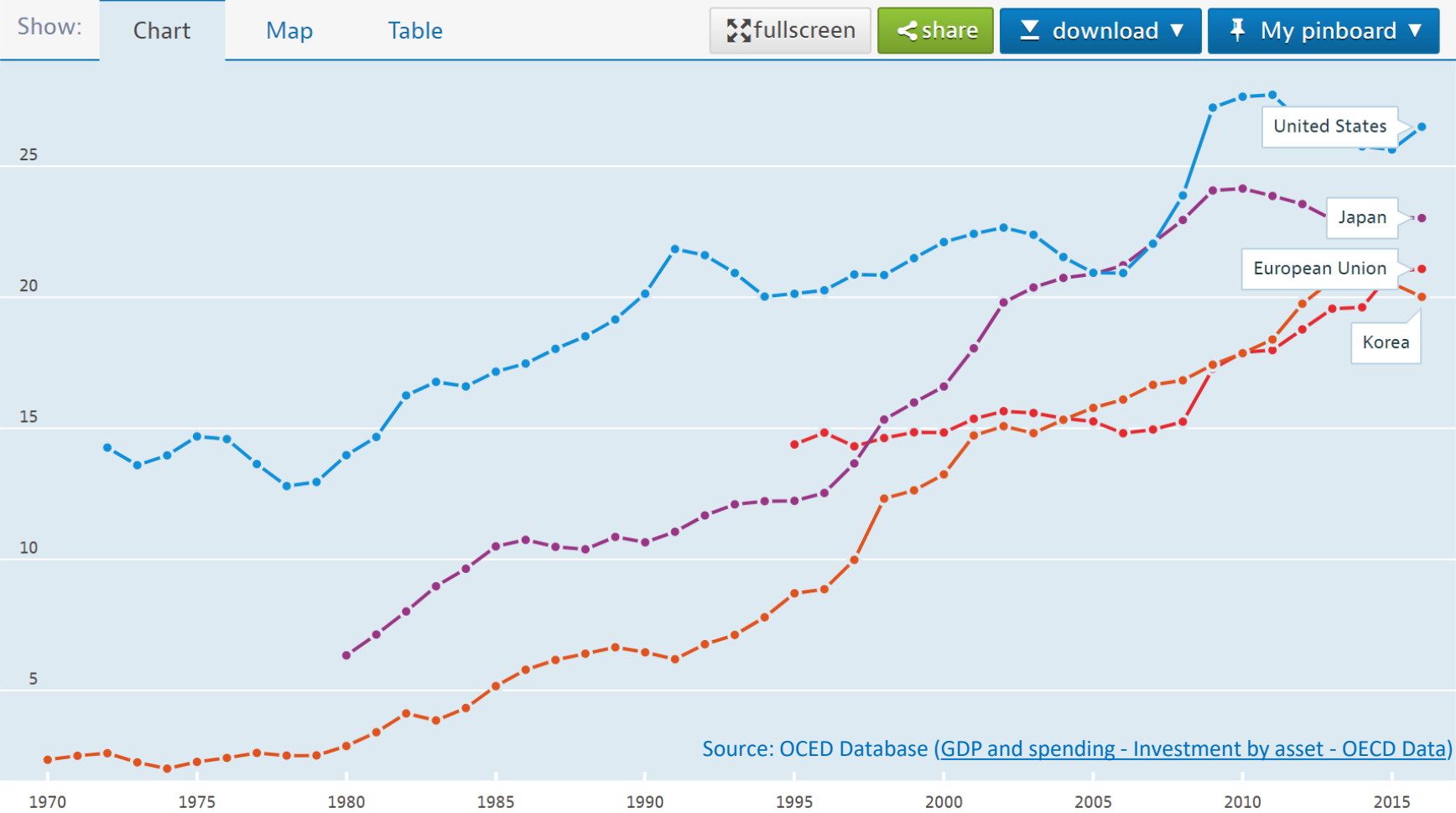
A SHIFT IN THE DRIVERS OF INNOVATION



The conditions for innovation in production will depend on the effectiveness of institutional innovation

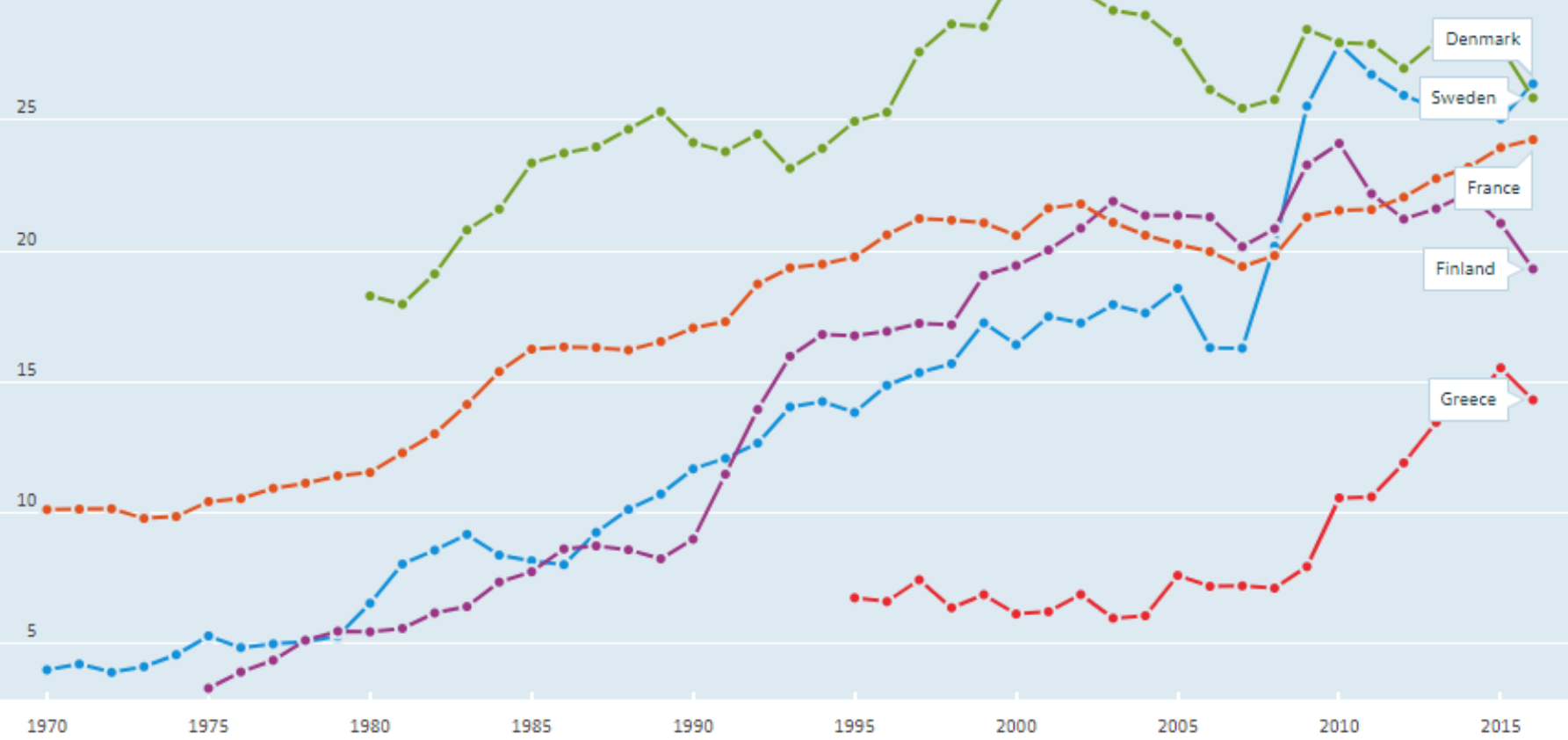
Investment by asset Intellectual property products, % of GFCF, 1970 – 2016

Source: National Accounts at a Glance



Source: OECD Database (GDP and spending - Investment by asset - OECD Data)

Investment in intangible assets, % of GFCF, 1970 – 2016



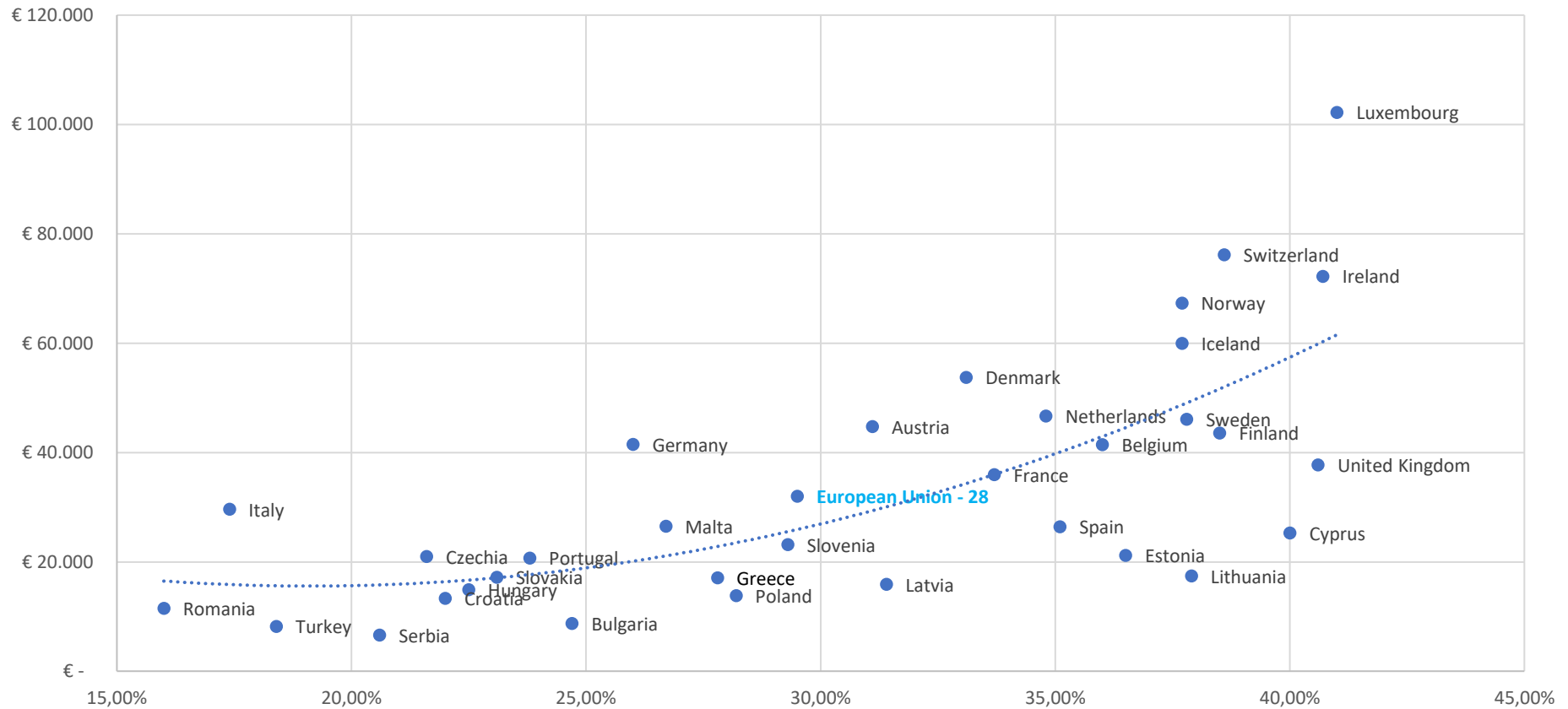
Source: OECD National Accounts Statistics: National Accounts at a Glance

Επιχειρηματικά μοντέλα και τρόπος παραγωγής



Προσαρμογή από Teece (2010)

GDP per capita and population % with tertiary education attainment in Europe (2019)



THREE MAIN SOURCES OF CRITERIA

to identify the likely directions of innovation in the next two or three decades

- **Recurring historical patterns** (features of deployment periods)
 - Innovation across all industries
 - ICT moving from 'supply push' to 'demand pull'
 - (More or less) reversal of income polarisation
- **Specificity of current conditions:**
 - Climate change
 - Limits to energy and materials supply
 - Geopolitical tensions and challenge to US hegemony
- **Characteristics and potential of the current ICT paradigm:**
 - Complex global coordination
 - Segmentation of markets, activities and technologies
 - Enabling materials and energy saving

Many factors often accelerate the occurrence of a technological breakthrough.



Significant demographic shifts

- Aging population
- Globalisation
- Migration



Sustained economic growth

- GDP growth
- Job growth
- Investment



Innovative political environments

- Tax breaks
- Legislation
- Lower barriers to market entry



Urgent societal needs

- Pandemics
- Human rights violations
- Natural disasters

A SOLUTION IN THREE STEPS

Stage one: **Intensive therapy**

Stage two: **Redesign financial architecture**

Stage three: **Enable structural shift**

**They all require institutional innovation
to facilitate financial, production and consumption innovation**

FOUR CRUCIAL DEVELOPMENTS WILL DEPEND ON ADEQUATE INSTITUTIONAL INNOVATION:

1. Whether finance abandons the casino and concentrates on financing production
2. Whether the context is clearly favourable to production innovation
3. Whether society fully benefits from the potential of the new technologies
4. Whether widespread production globalisation replaces trade and finance globalisation

ADEQUATE?

Consistent with the paradigm

Positive sum-game between business and society

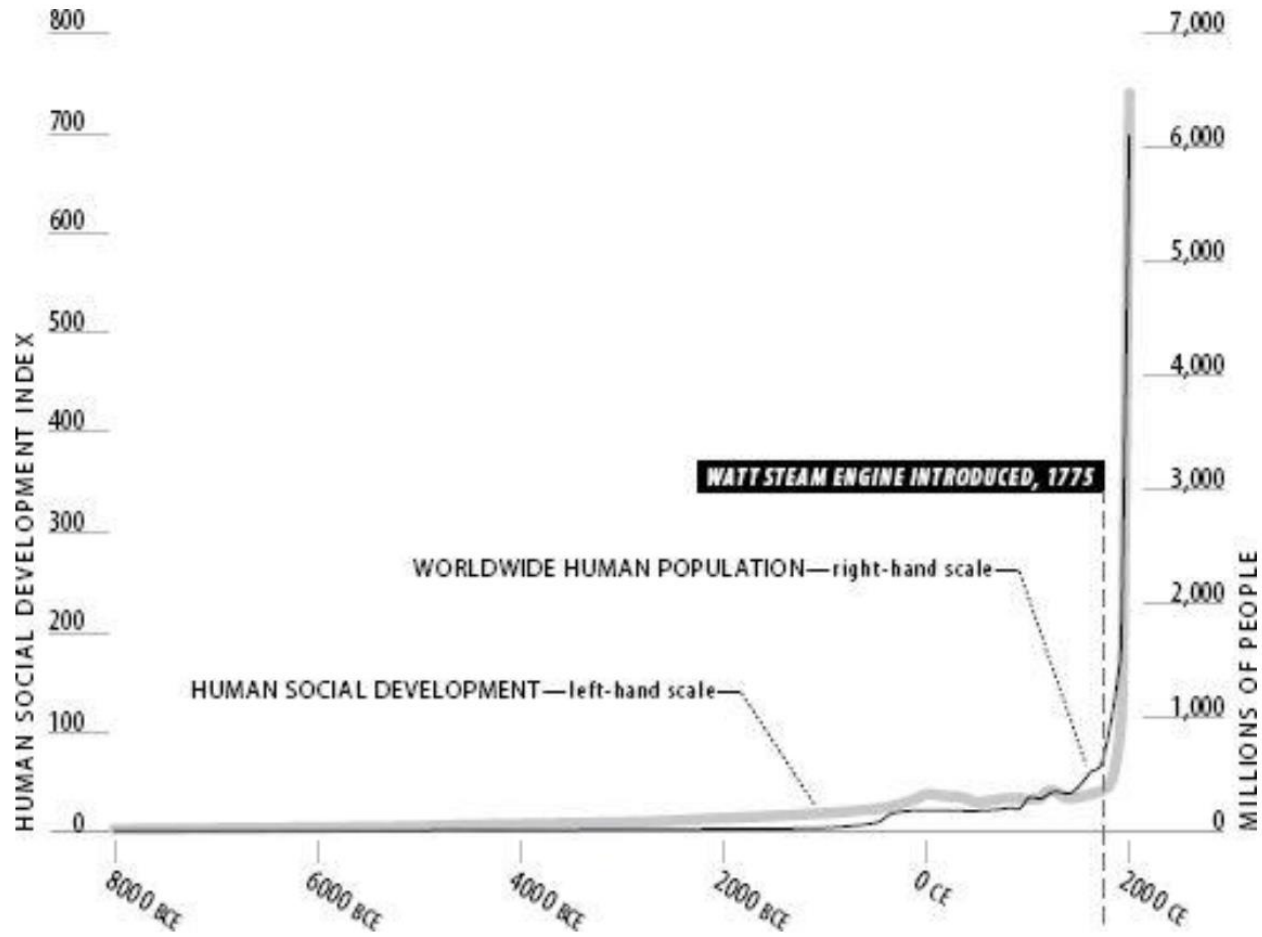
The challenges for institutional innovation

FROM FINANCE TO PRODUCTION

HOW TO...?

- Discourage the casino and favour profit making from wealth creation
- Establish common global rules (regulatory floor) with power of enforcement
- Facilitate the intangible economy
- Provide adequate credit and support for KISEs (knowledge intensive service enterprises)
- Make venture capital a permanent and accessible component of the financial system
- Etc.

FIGURE 1.2 What Bent the Curve of Human History? The Industrial Revolution.



Πηγή: Brynjolfsson & McAfee (2013)

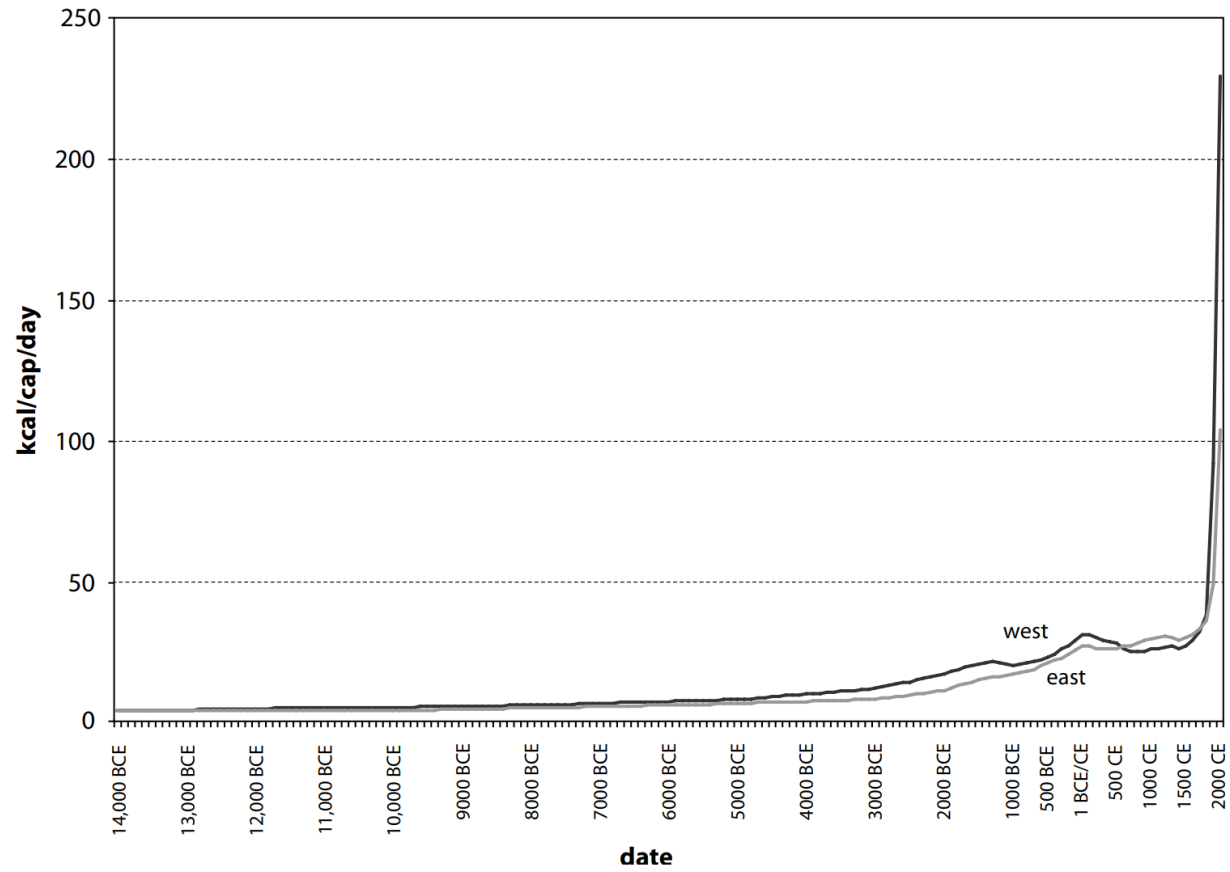


Figure 2.5. Eastern and Western energy capture, 14,000 BCE–2000 CE, shown on a linear-linear scale.

(Morris, 2013)

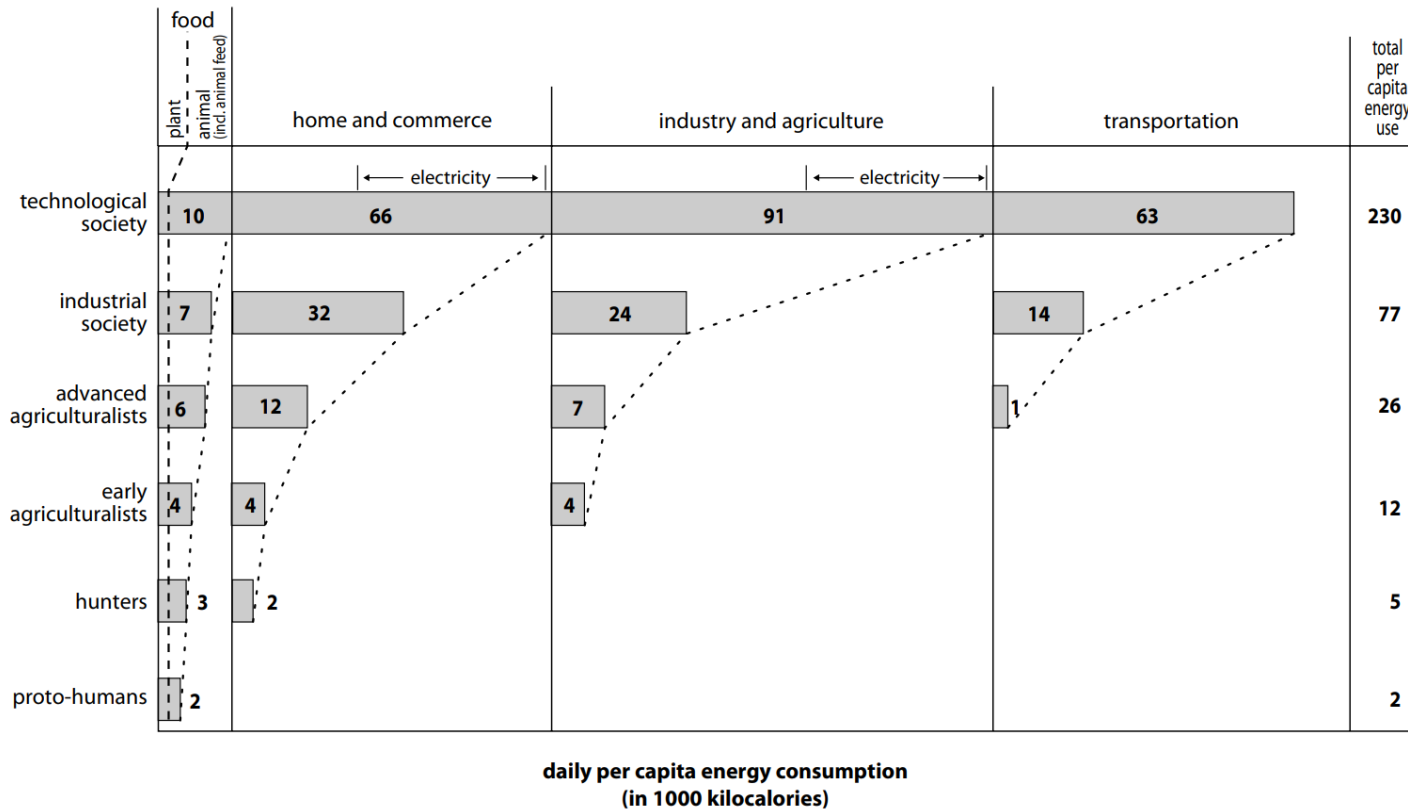
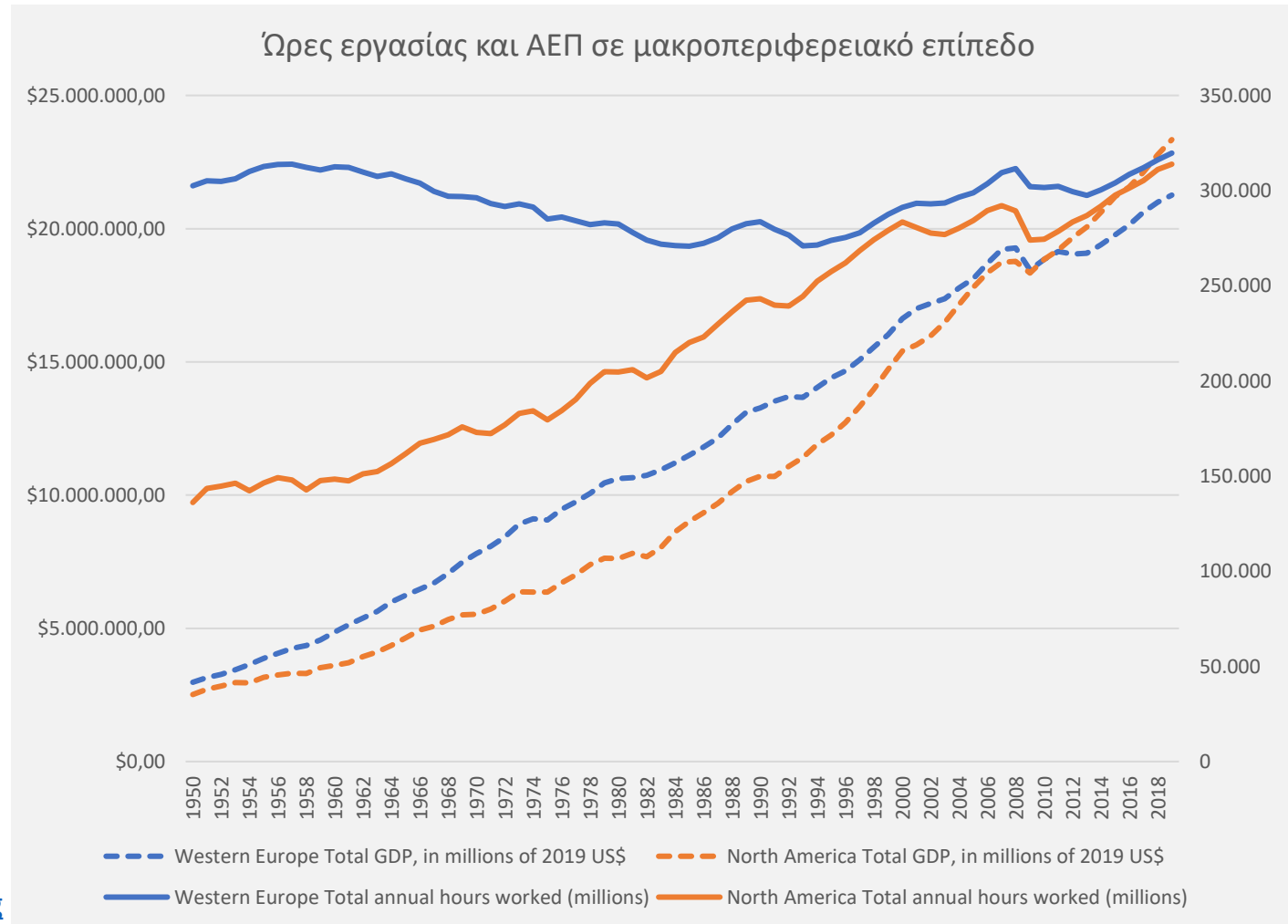


Figure 3.1. Earl Cook's diagram of energy consumption at different stages of social development. *Source:* Cook, "Flow of Energy," 137.

(Morris, 2013)

Εργασία και τεχνολογική αλλαγή

- “παράδοξο χαμηλής ανεργίας”?
- Άεργη μεγέθυνση
- Επισφάλεια
- Εργαζόμενοι φτωχοί
- Πολλαπλές ανισότητες
- *Η 2^η εποχή της μηχανής*



Πηγή: [conference-board.org](https://www.conference-board.org)

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