«*Τα πάντα ρεί*»
Γνώση, Τεχνολογία, Καινοτομία και Οικονομία

Τεχνολογική Στρατηγική

- ***ΔΠΜΣ «Επιχειρηματικότητα»***

Γεώργιος Σταμπουλής

Τμήμα Οικονομικών Επιστημών

ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ

Key issues

- What is innovation?
- What is innovative activity?
- Diffusion of innovation
- Increasing returns
- Network effects
- Learning
- Technological change
- Path dependence
- Techno-economic paradigms (and Structural crises)

A new agenda

- Development vs Growth
  - Stiglitz-Sen-Fitoussi Commission
- Sustainability
- Change
- Innovation
- Technical change
- Entrepreneurship

Solow's residual - 1956

- Comparative static exploration
- Causes of US manufacturing growth 1911-56
- Observed growth in labour productivity
    - 12.5% 'explained' by increments in the stock of capital
    - "Residual" 87.5%: unexplained 'technological change' or 'improvement in productivity'

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

Innovation

- Different from invention
  - Time lag
- First economic application of a process or production of a product (artifact) or service
- Coupling of new technology with a market (a need)
- Cumulative
- Increasing returns to innovation
- Aim-Result as well as Process

Types of innovation

- Product or service innovation
- Process innovation
- Raw material innovation
- Market innovation
- Organizational innovation

Innovation process

- Industrial innovation process:
  - all the activities from idea conception, requirements analysis or problem identification to the introduction of a new (or improved) product or the application of a new (or improved) process
  - includes industrial design, R&D, engineering, production and logistics, marketing and sales
- Fuzzy
- Non-linear
- Interdependent
- Context specific: imitator–adaptor as innovator

Innovative activities – Locus?

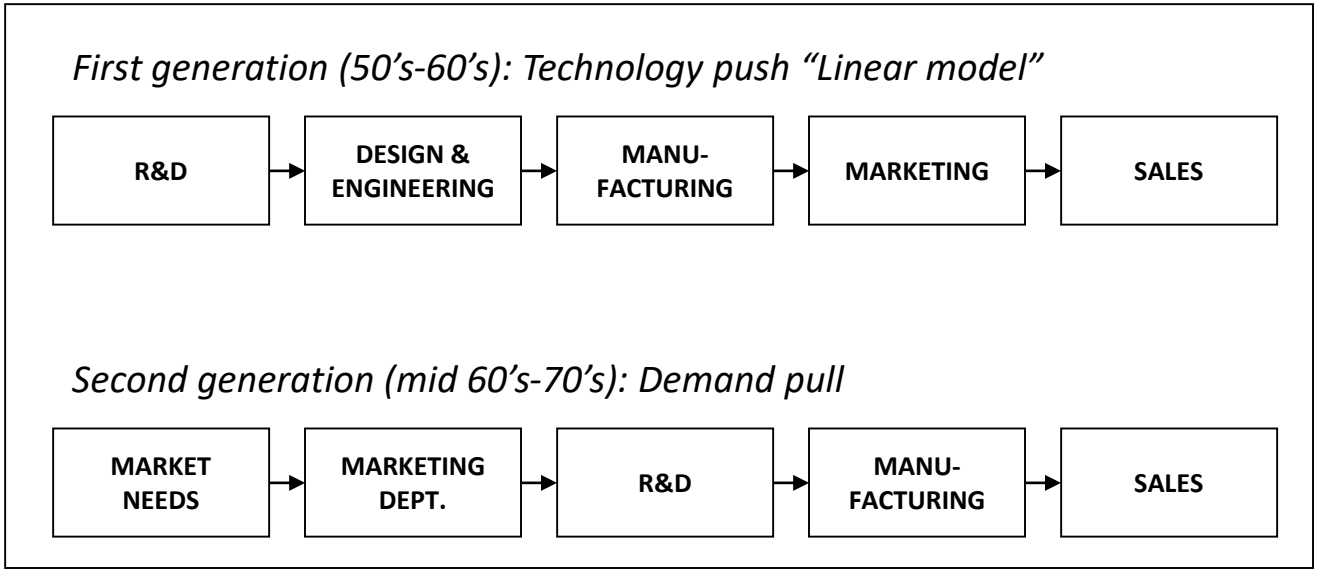
- Fundamental research
- Applied research
- R&D
- Experimental development
- Design engineering
- Production engineering / quality control
- Technical services
- Patents
- Scientific and technical information scanning
- Education and training
- Long-range forecasting and product planning

Source: Freeman and Soete (1997 ,p. 267)

Innovation as Learning

- Transformation of knowledge about technology to knowledge about the production of products
- Learning occurs in all types of innovative activities from R&D to after-sales-services
- Learning occurs before and after
- Innovation often requires unlearning

First and second generation models



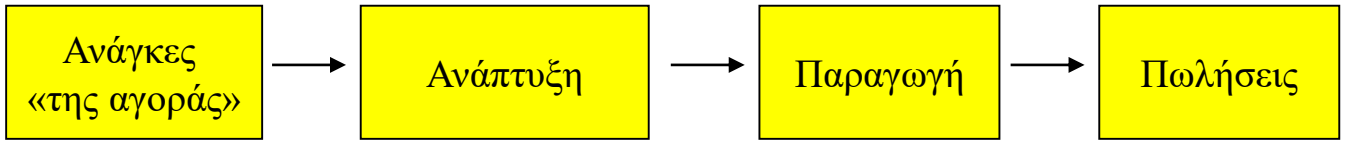
Μοντέλα καινοτομικής διαδικασίας

- Ο Rothwell διακρίνει πέντε γενιές μοντέλων της καινοτομικής διαδικασίας:
  - 1η: μοντέλα τεχνολογικής ώθησης (technology-push)
  - 2η: μοντέλα πρωτοκαθεδρίας των αναγκών της αγοράς (market-pull)
  - 3η: μοντέλα ‘παντρέματος’ της τεχνολογικής εξέλιξης με τις ανάγκες της αγοράς (coupling model)
  - 4η: μοντέλα λειτουργικής ολοκλήρωσης (integrated model), και
  - 5η: μοντέλα συστημικής ολοκλήρωσης και δικτύωσης (systems integration and networking - SIN)

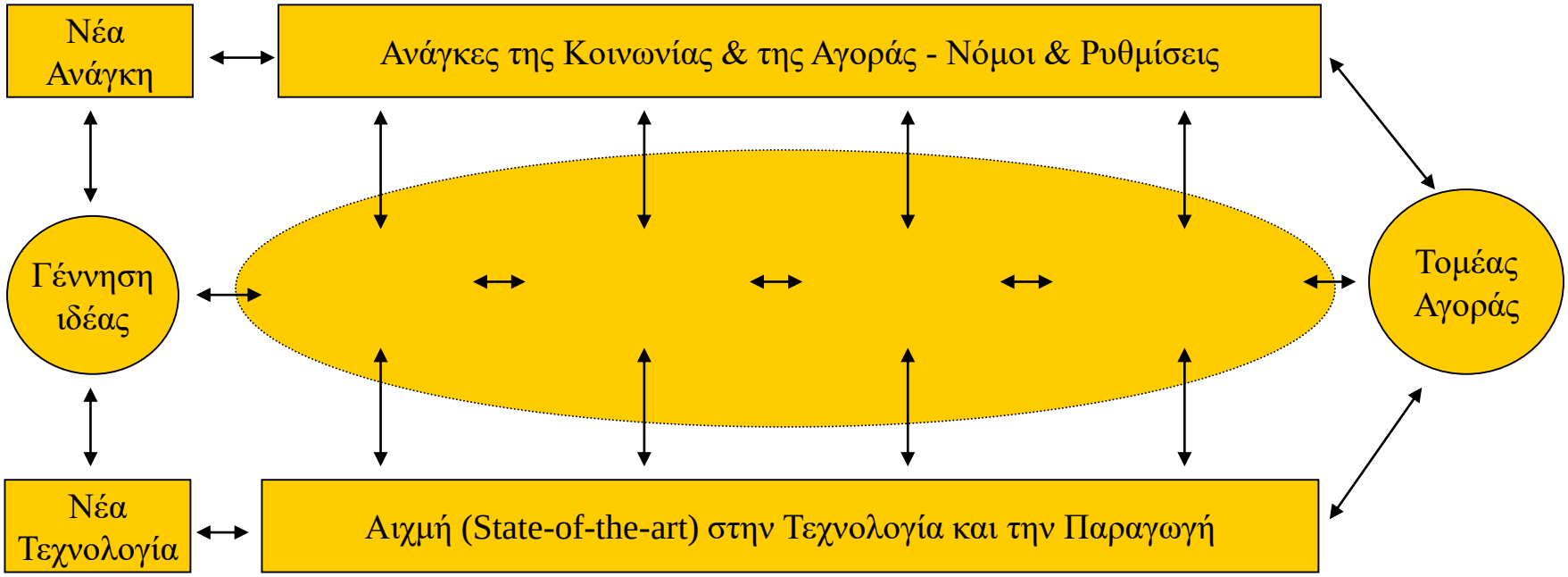
Γραμμικά Μοντέλα της Καινοτομικής Διαδικασίας

(α) Τεχνολογική Ώθηση (Technology Push)

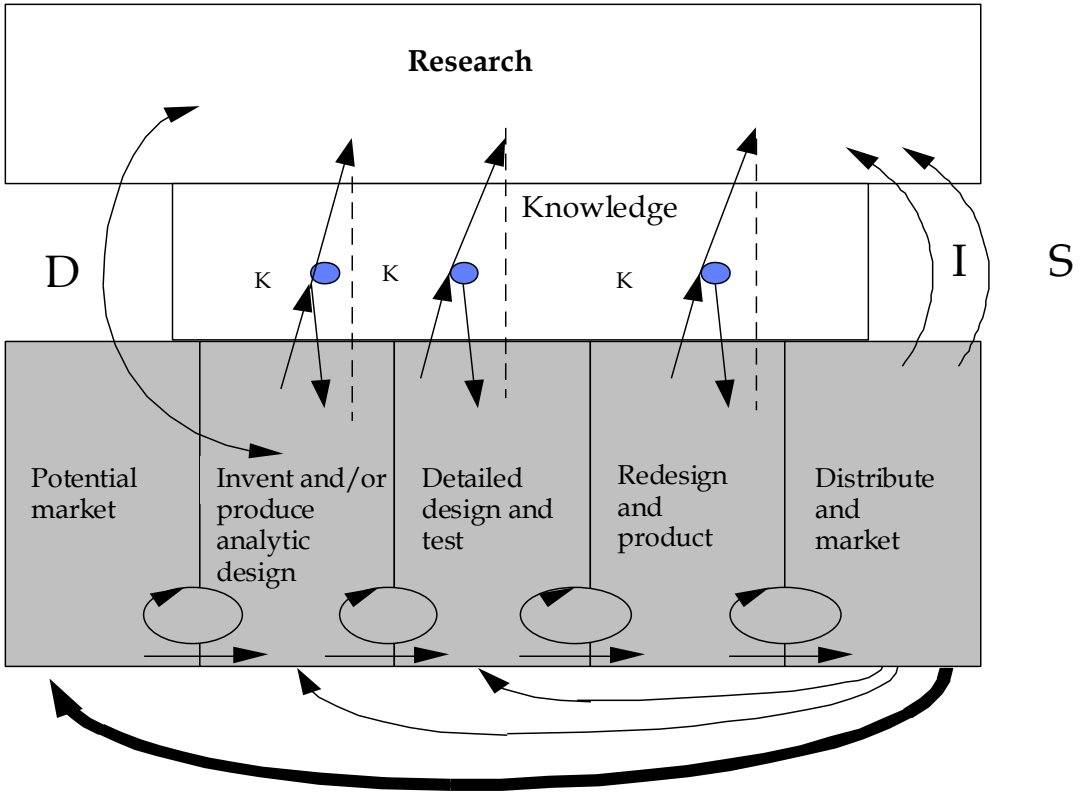
(α) Έλξη από την Αγορά (Market Pull)



Το ‘συζευκτικό’ (coupling) μοντέλο της καινοτομικής διαδικασίας



3rd generation model

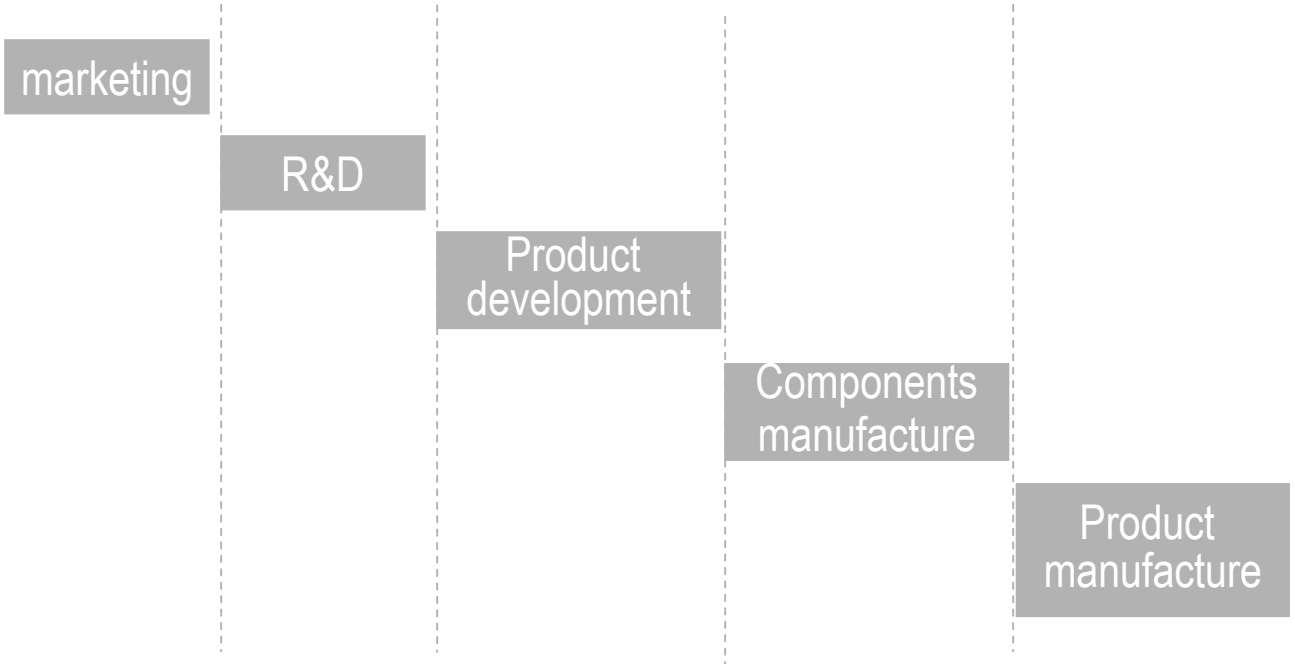


D: Direct link to and from research from problems in invention and design

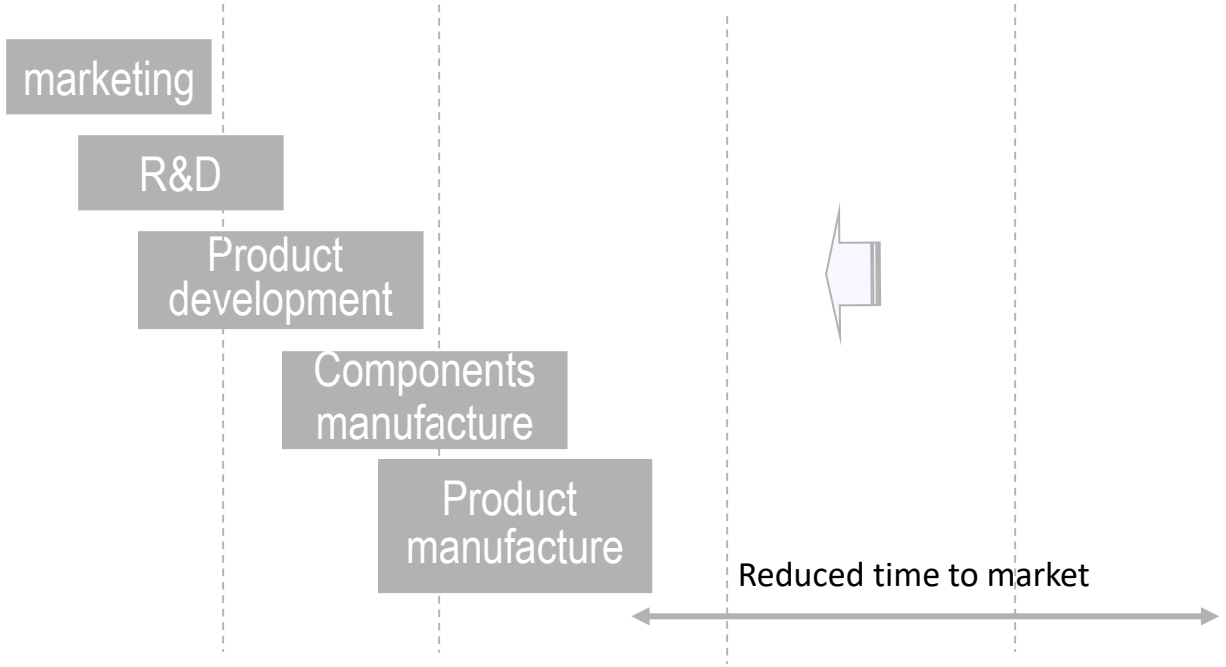
I: Support of scientific research by instruments, machines, tools

S: Support of research in sciences underlying the product areas

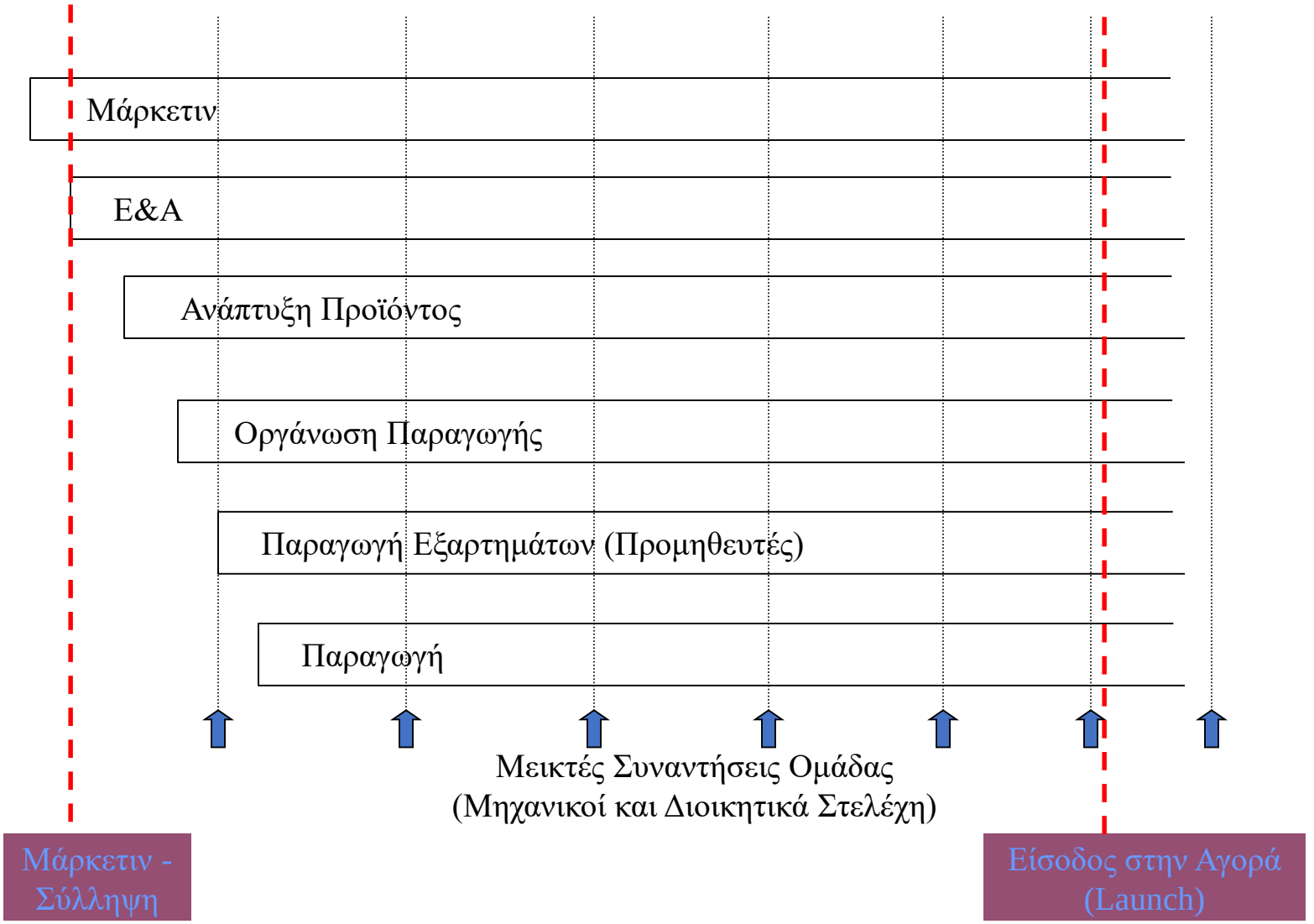
4th generation model



4th generation model - concurrency



Παράλληλη Ανάπτυξη (Concurrent Engineering)



Συστημική ολοκλήρωση και δικτύωση (systems integration and networking - SIN)

- Ευρύτερη ολοκλήρωση οργανωτικών μονάδων και τεχνικών συστημάτων:
  - παράλληλα και ολοκληρωμένη (δια-τμηματικά) διαδικασία ανάπτυξης
  - ανάμιξη προμηθευτών νωρίς στην ανάπτυξη προϊόντων
  - εμπλοκή προωθημένων χρηστών αιχμής στην ανάπτυξη προϊόντων
  - χρήση οριζόντιων τεχνολογικών συνεργασιών όπου χρειάζεται

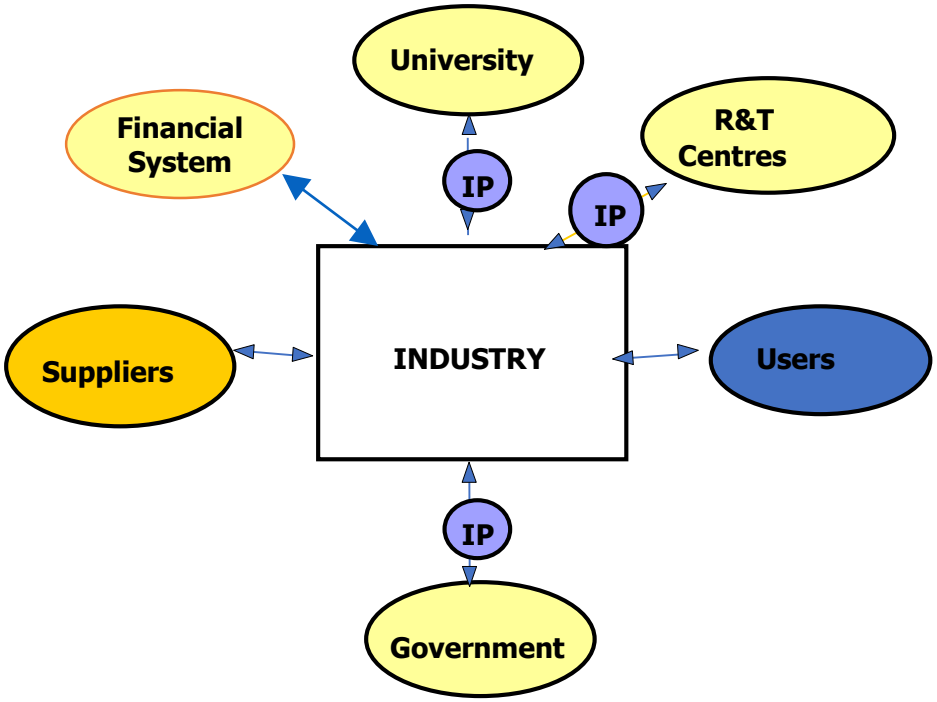
- Πιο επίπεδες, ευέλικτες οργανωτικές δομές, για ταχύτερη και πιο αποτελεσματική λήψη αποφάσεων:
  - ενίσχυση του ρόλου, των αρμοδιοτήτων και του κύρους των μεσαίων και κατώτερων στελεχών,
  - αντίστοιχη ενίσχυση των υποστηρικτών προϊόντων και των επικεφαλής έργων

Συστημική ολοκλήρωση και δικτύωση (systems integration and networking - SIN)

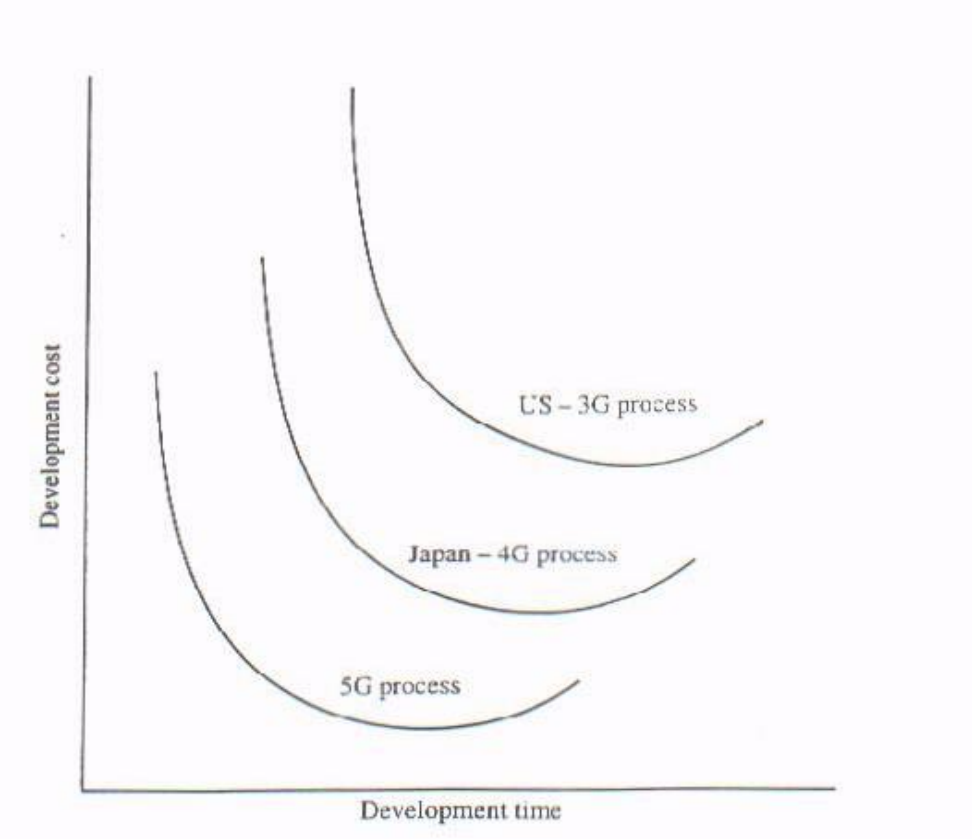
- Πλήρως αναπτυγμένες εσωτερικές βάσεις δεδομένων:
  - αποτελεσματικά συστήματα διανομής δεδομένων
  - μετρήσεις (metrics) ανάπτυξης προιόντος, έμπειρα συστήματα, υπολογιστικά ευρετικά συστήματα (computer-based heuristics)
  - χρήση 3D-CAD συστημάτων και μοντελοποίησης με τη βοήθεια προσομοίωσης
  - διασυνδεδεμένα συστήματα CAD/CAE για την ενίσχυση της ευελιξίας και της κατασκευασιμότητας των προϊόντων από τα πρώτα στάδια

- Αποτελεσματικές εξωτερικές διασυνδέσεις για την ανταλλαγή δεδομένων και πληροφοριών:
  - συνεργασία με τους προμηθευτές κατά την ανάπτυξη με διασυνδεδεμένα συστήματα CAD,
  - χρήση CAD στην επαφή με τους πελάτες
  - αποτελεσματικοί δίαυλοι ανταλλαγής δεδομένων με τους συνεργάτες σε E&A

5TH generation model



Χρόνος και κόστος



Rothwell's five generations of innovation models

TABLE 2.2 Rothwell's five generations of innovation models

Generation	*Key features*
First and second	Simple linear models – need pull, technology push
Third	Coupling model, recognizing interaction between different elements and feedback loops between them
Fourth	Parallel model, integration within the firm, upstream with key suppliers and downstream with demanding and active customers, emphasis on linkages and alliances
Fifth	Systems integration and extensive networking, flexible and customized response, continuous innovation

Μοντέλα καινοτομικής διαδικασίας - Παρατηρήσεις - Ι

Παρατηρούμε ότι από τα γραμμικά στα πολύπλοκα δυναμικά μοντέλα αλλάζει το αντικείμενο των μοντέλων

- 1 και 2: πηγές καινοτομίας - στο επίπεδο της οικονομίας
- 3 και 4: καινοτομική διαδικασία - στο επίπεδο της επιχείρησης/μονάδας, το 3 περιβάλει το 4, το οποίο εστιάζει σε δύο κρίσιμα εσωτερικά στοιχεία της διαδικασίας, την παράλληλη και ολοκληρωμένη φύση της
- 5: στρατηγική θεώρηση - συνολικά η επιχείρηση σε στρατηγική θεώρηση, η άσκηση της διαχείρισης υπερβαίνει τα θεσμικά όρια της επιχειρηματικής δομής

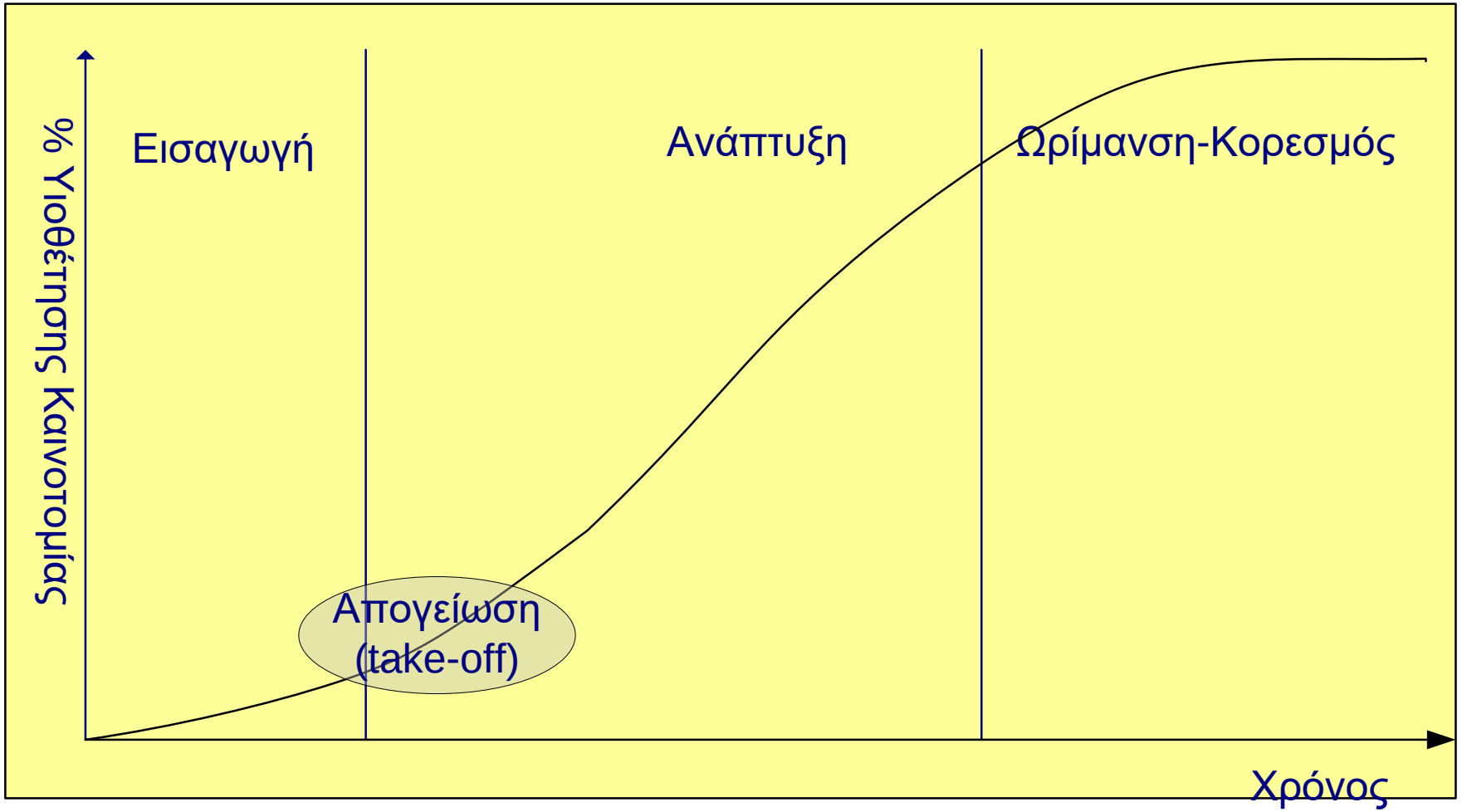
Η αλλαγή αυτή στη θεώρηση συμβαδίζει και με τις προτεραιότητες στην οικονομία. Έτσι, κατά την δεκαετία του 1990 τα κυρίαρχα ζητήματα στην επιχειρησιακή στρατηγική ήταν:

- διεπιχειρησιακή συνεργασία (στρατηγική δικτύωσης)
- τεχνολογική συσσώρευση (τεχνολογική στρατηγική)
- ολοκλήρωση στρατηγικών προϊόντων και παραγωγής (σχεδιασμός με κριτήριο την ‘κατασκευασιμότητα’)
- ευελιξία (οργανωτική, διαχειριστική, προϊόντων, παραγωγής)
- ποιότητα και επίδοση προϊόντων (στρατηγική διαφοροποίησης)
- το περιβάλλον (περιβαλλοντική στρατηγική), και
- η ταχύτητα ανάπτυξης και εισαγωγής στην αγορά (speed-to-market) (time-based strategy)

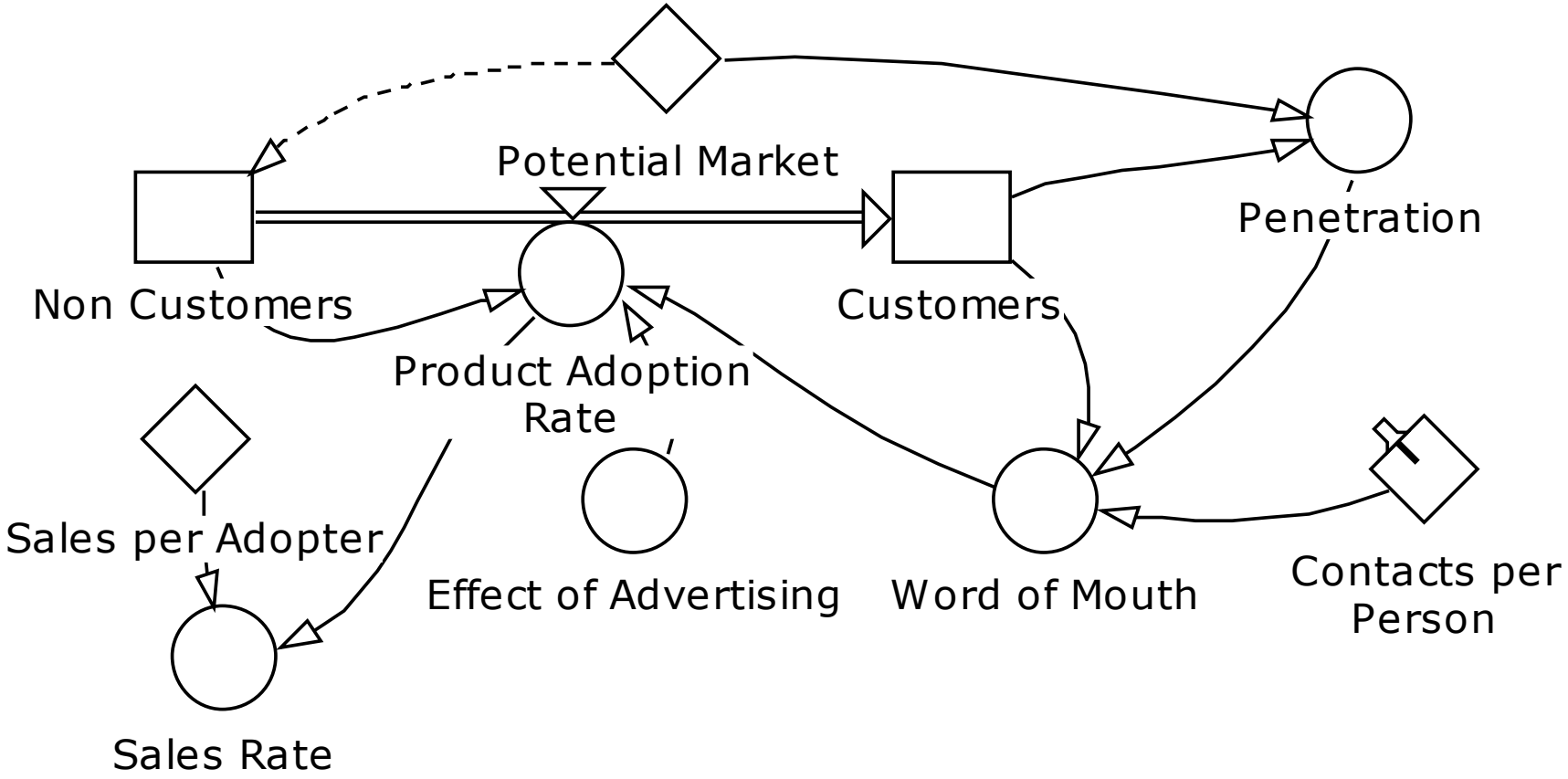
Diffusion

- The rate of adoption or assimilation of new products or process by consumers or organizations
- Diffusion rate is critical for:
  - The rate of return on the investment in the development of new technology
  - The accomplishment of economies of scale
  - Further improvement of the technology or investment in new
  - Development of related technologies

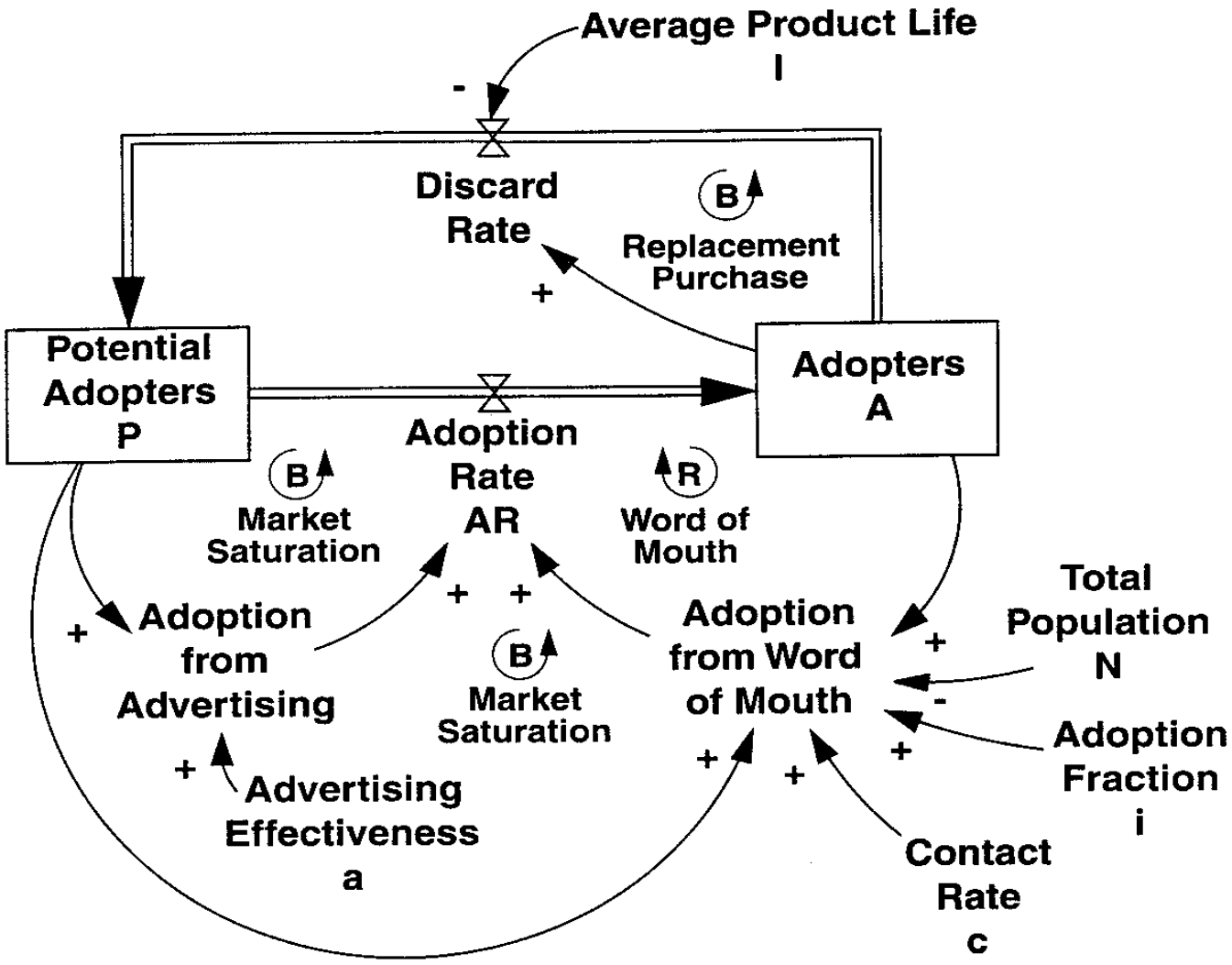
Διάχυση Καινοτομίας



Dynamics of adoption



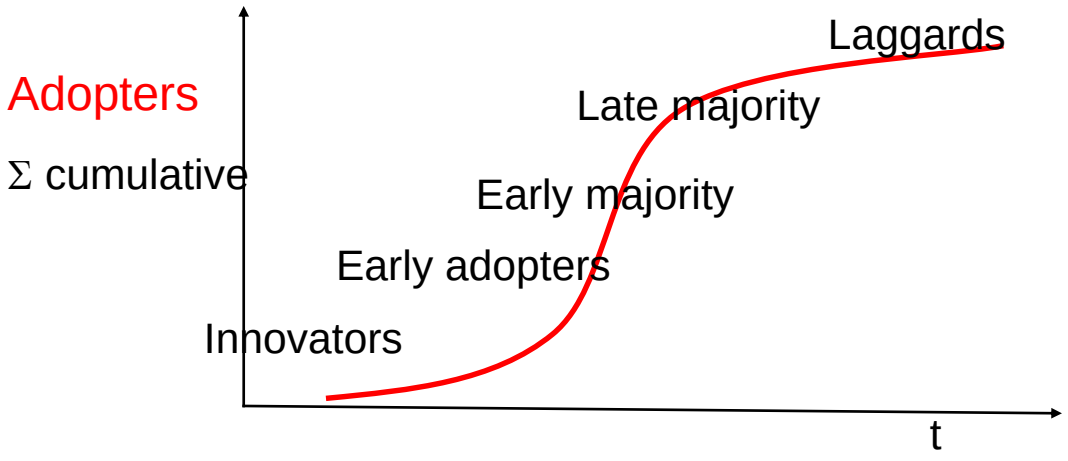
Πηγή: Sterman (2000)



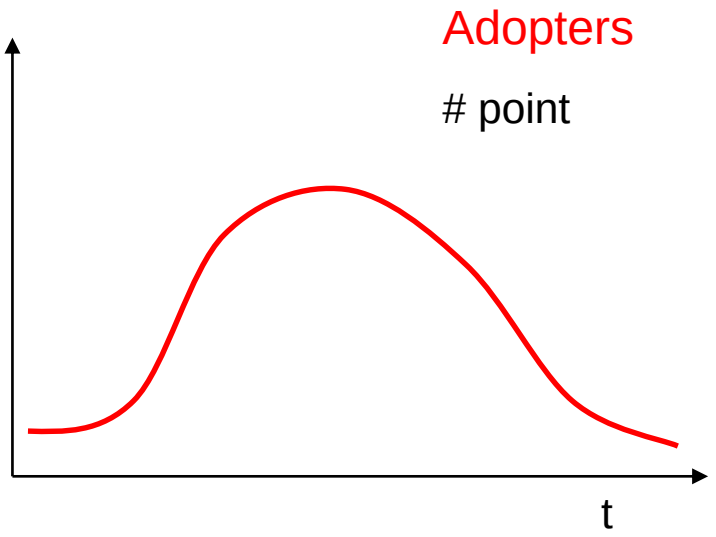
Πηγή: Sterman (2000)

Patterns of innovation diffusion

Cumulative diffusion (stock)



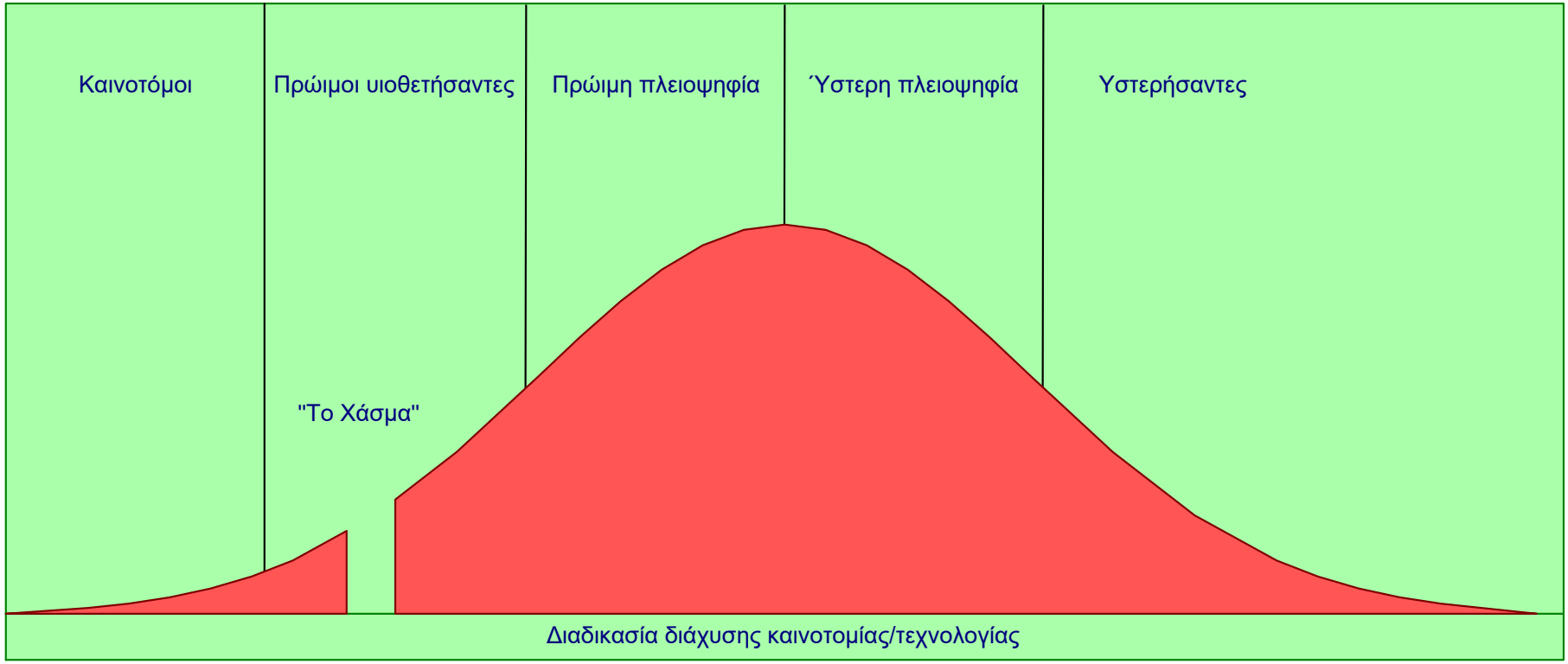
Point diffusion (flow)



Rogers E. M., (1965)

Bass, F. M. (1969)

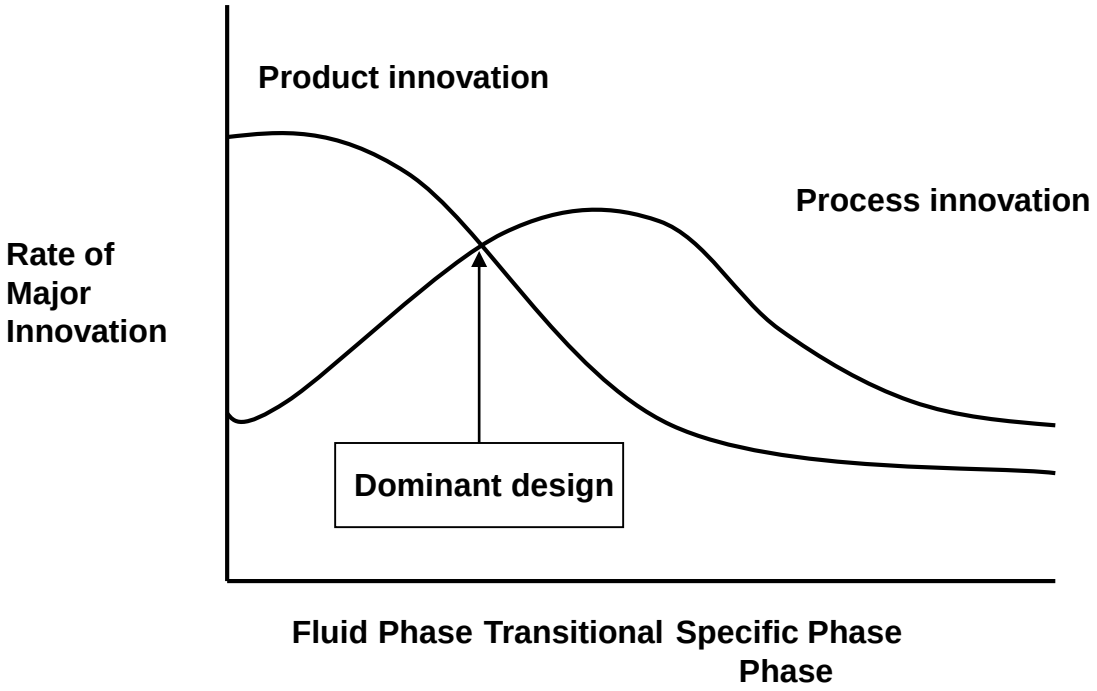
Η καμπύλη του ρυθμού διάχυσης



Κατηγορίες και χαρακτηριστικά των υιοθετούντων την καινοτομία

Κατηγορία	Κοινά χαρακτηριστικά
Καινοτόμοι (Innovators)	2.5%. Χρειάζονται μικρότερο χρόνο υιοθέτησης από οποιοδήποτε άλλο γκρουπ. Παράτολμοι, κινητικοί, τολμηροί. Εκείνοι που ρισκάρουν. Οικονομικοί πόροι για την απορρόφηση μη επικερδών καινοτομιών, κατανόηση και εφαρμογή σύνθετης τεχνικής γνώσης για την ανταπόκριση με έναν μεγάλο βαθμό αβεβαιότητας
Πρώιμοι υιοθετήσαντες (Early Adopters)	13,5%. Ανερχόμενοι της κοινωνικής κινητοποίησης. Μεγαλύτερος βαθμός της ηγεσίας γνώμης, μοντέλο κανόνας στο κοινωνικό σύστημα, σεβασμός από τα ισότιμα μέλη, επιτυχημένοι .
Πρώτη πλειοψηφία (Early Majority)	34%. Αλληλεπιδρούν συχνά με ομοίους τους (στον κοινωνικό περίγυρο), σπάνια κρατάνε τη θέση του ηγέτη άποψης, εσκεμμένα πριν την υιοθέτηση μιας νέας ιδέας .
Ύστερη πλειοψηφία (Late Majority)	34%. Αντιδρούν στην πίεση από τους ομοίους τους, οικονομική αναγκαιότητα, σκεπτικιστές, προσεκτικοί .
Υστερήσαντες (Laggards)	16% Καθόλου ηγεσία γνώμης. Απομονωμένοι. Σημείο αναφοράς αποτελεί το παρελθόν. Δύσπιστοι για τις καινοτομίες καινοτομίες, οι διαδικασίες λήψης απόφασης που αφορούν καινοτομίες είναι χρονοβόρες, με περιορισμένους πόρους

Product Cycle

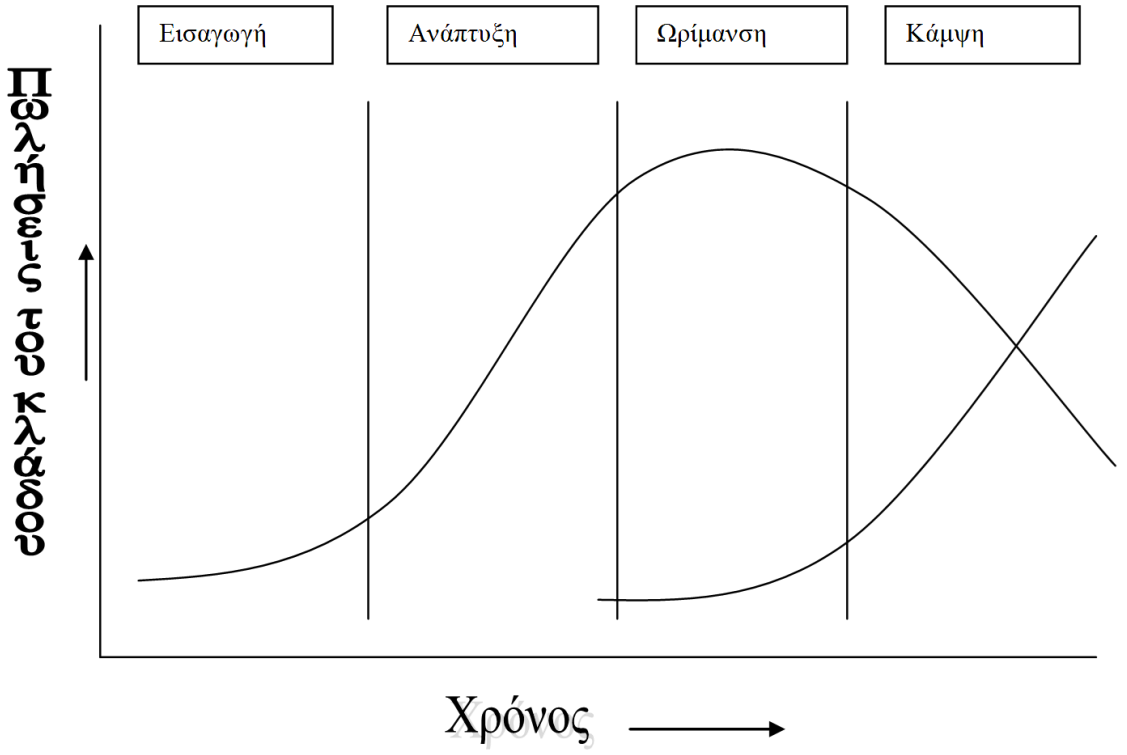


Source: Utterback (1994, p. xvii)

Ο κύκλος ζωής προϊόντος

αναλυτικό εργαλείο: απεικονίζει την χρονική εξέλιξη του όγκου πωλήσεων ενός νέου προϊόντος

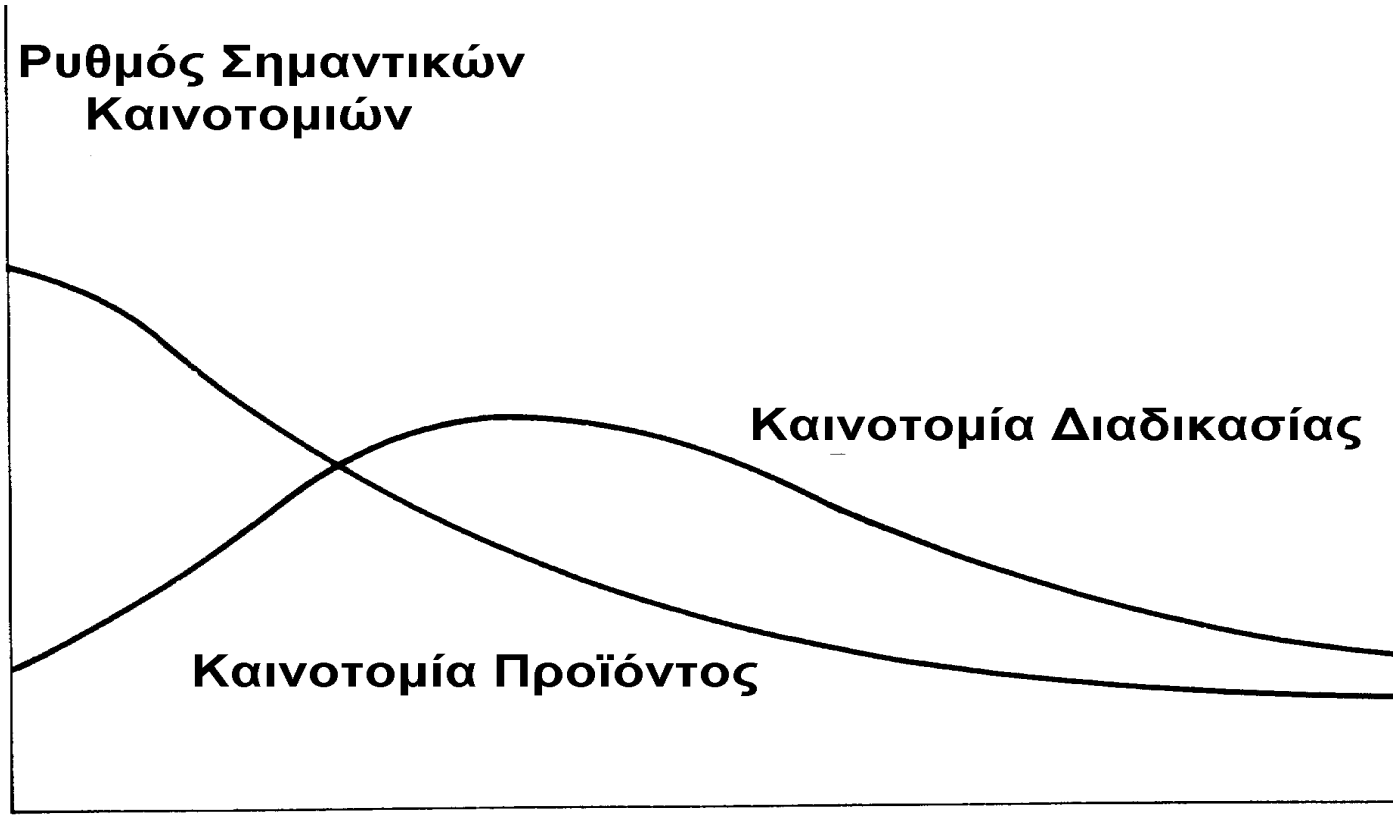
- τέσσερις φάσεις
  - εισαγωγή
  - ανάπτυξη
  - ωριμότητα
  - κάμψη



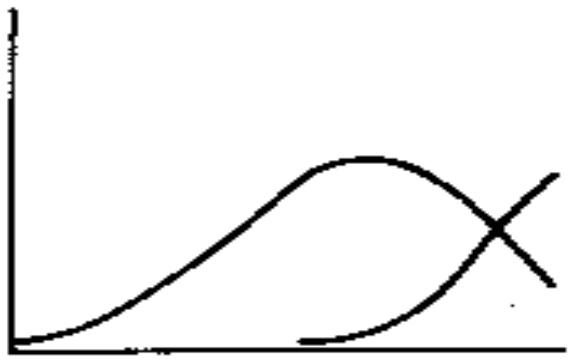
Συσχέτιση μεταξύ των διαστάσεων της καινοτομίας

- Utterback and Abernathy (1975-78)
  - «τα χαρακτηριστικά της καινοτομικής διαδικασίας και οι καινοτομικές απόπειρες μιας επιχείρησης θα διαφέρουν συστηματικά σύμφωνα με το περιβάλλον και τη στρατηγική ανάπτυξης και ανταγωνισμού της επιχείρησης, και με το στάδιο ανάπτυξης της τεχνολογίας παραγωγής που χρησιμοποιείται από την επιχείρηση και τους ανταγωνιστές της», ανεξάρτητα από τομέα και τεχνολογία.
- μονάδα ανάλυσης η παραγωγική μονάδα
- η ανάλυση εστιάζει στη μεταβολή της φύσης της καινοτομικής διαδικασίας
- υπαινίσσεται σαφείς επιλογές για τη στρατηγική των επιχειρήσεων

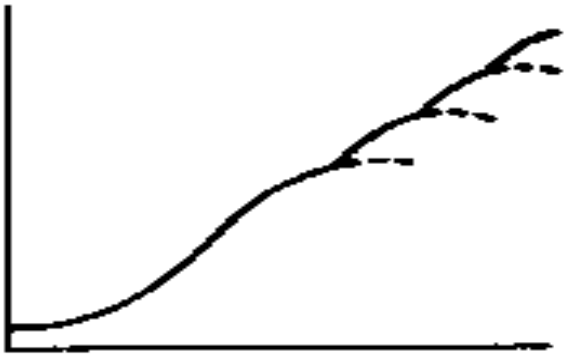
Συσχέτιση μεταξύ των τύπων καινοτομίας (συνέχεια)



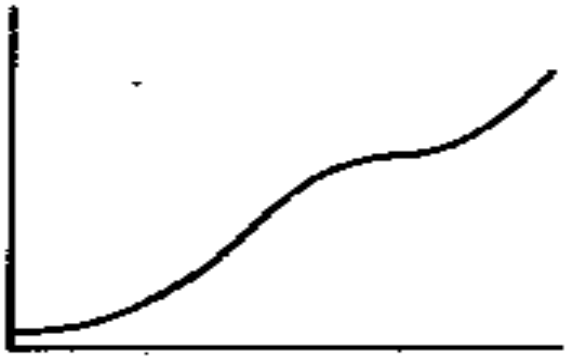
Παραλλαγές του απλού κύκλου ζωής



α) Υποκατάσταση



β) Επεκτάσεις του κύκλου ζωής



γ) Αλλαγή στην τεχνολογία

δ) Εκτεταμένη φάση ωριμότητας

πηγή: Rothwell & Zegvelt (1984)

TABLE 1.2 Stages in innovation life cycle

Innovation characteristic	*Fluid pattern*	*Transitional phase*	*Specific phase*
Competitive emphasis placed on . . .	Functional product performance	Product variation	Cost reduction
Innovation stimulated by . . .	Information on user needs, technical inputs	Opportunities created by expanding internal technical capability	Pressure to reduce cost, improve quality, etc.
Predominant type of innovation	Frequent major changes in products	Major process innovations required by rising volume	Incremental product and process innovation
Product line	Diverse, often including custom designs	Includes at least one stable or dominant design	Mostly undifferentiated standard products
Production processes	Flexible and inefficient – aim is to experiment and make frequent changes	Becoming more rigid and defined	Efficient, often capital intensive and relatively rigid

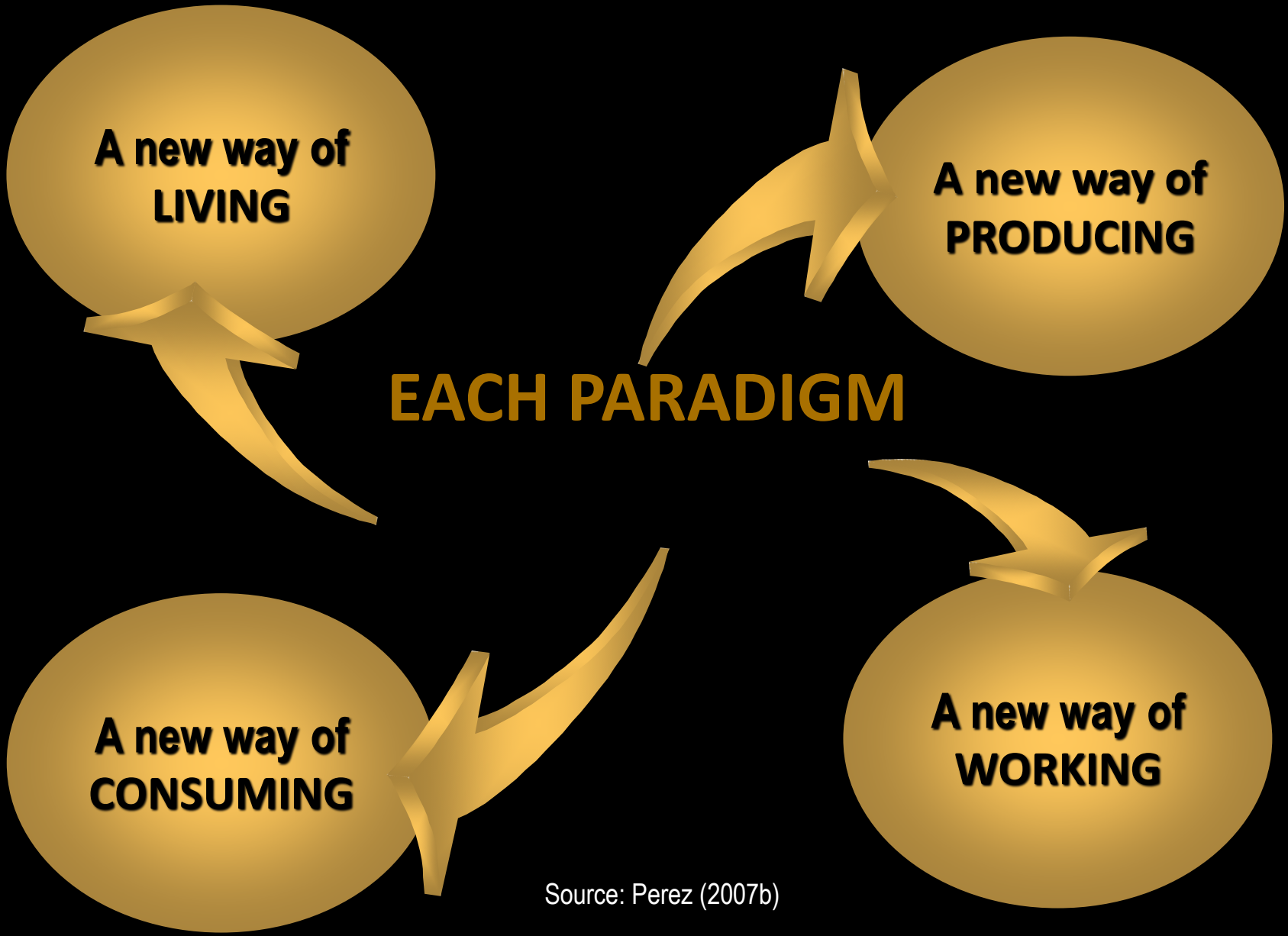
Ταξινόμηση κλάδων κατά Pavitt

Σε αντίθεση με τους U-A, οι Pavitt και Patel υποστηρίζουν ότι η τεχνολογική αλλαγή έχει ισχυρά κλαδικά χαρακτηριστικά:

- το μέγεθος των επιχειρήσεων που καινοτομούν
- τον τύπο του προϊόντος που παράγουν
- τους στόχους της καινοτομίας
- τις πηγές της καινοτομίας
- τον τόπο της καινοτομίας

Διακρίνουν πέντε τύπους κλάδων/τεχνολογικές τροχιές:

- ηγεμονευόμενους από τους προμηθευτές
- μεγάλης κλίμακας
- εντάσεως πληροφορίας
- εδραιωμένους στην επιστήμη
- εξειδικευμένους προμηθευτές



Source: Perez (2007b)

Αλλαγές στο τεχνο-οικονομικό παράδειγμα

(Freeman and Perez, 1988, pp 47-58)

- «συνδυασμός αλληλοσχετιζόμενων καινοτομιών προϊόντος, διαδικασίας, οργανωτικών και διοικητικών, που ενσωματώνει ένα κβαντικό άλμα στην δυνατή παραγωγικότητα για όλη ή το μεγαλύτερο μέρος της οικονομίας και ανοίγει ένα ασυνήθιστα ευρύ φάσμα ευκαιριών για επενδύσεις και κέρδη»

- σε κάθε νέο τεχνο-οικονομικό παράδειγμα, ένας συγκεκριμένος παραγωγικός πόρος ή ένα σύνολο αυτών, ο οποίος μπορεί να προσδιορισθεί ως ο 'πόρος κλείδί' του παραδείγματος, εκπληρώνει τις παρακάτω συνθήκες:
  - εμφανώς «χαμηλό και ταχέως μειούμενο κόστος»
  - «φαινομενικά, σχεδόν απεριόριστη προσφορά για μακρές περιόδους»
  - «εμφανείς δυνατότητες για την ενσωμάτωση του νέου πόρου κλειδί σε πολλά προϊόντα και διαδικασίες σε **<u>όλη την έκταση</u>** του οικονομικού συστήματος. Είτε άμεσα ή (συχνότερα) μέσα από ένα σύνολο αλληλοσχετιζόμενων καινοτομιών, οι οποίες και μειώνουν το κόστος και αλλάζουν την ποιότητα του παραγωγικού εξοπλισμού, της εργασίας και άλλων πόρων του συστήματος»

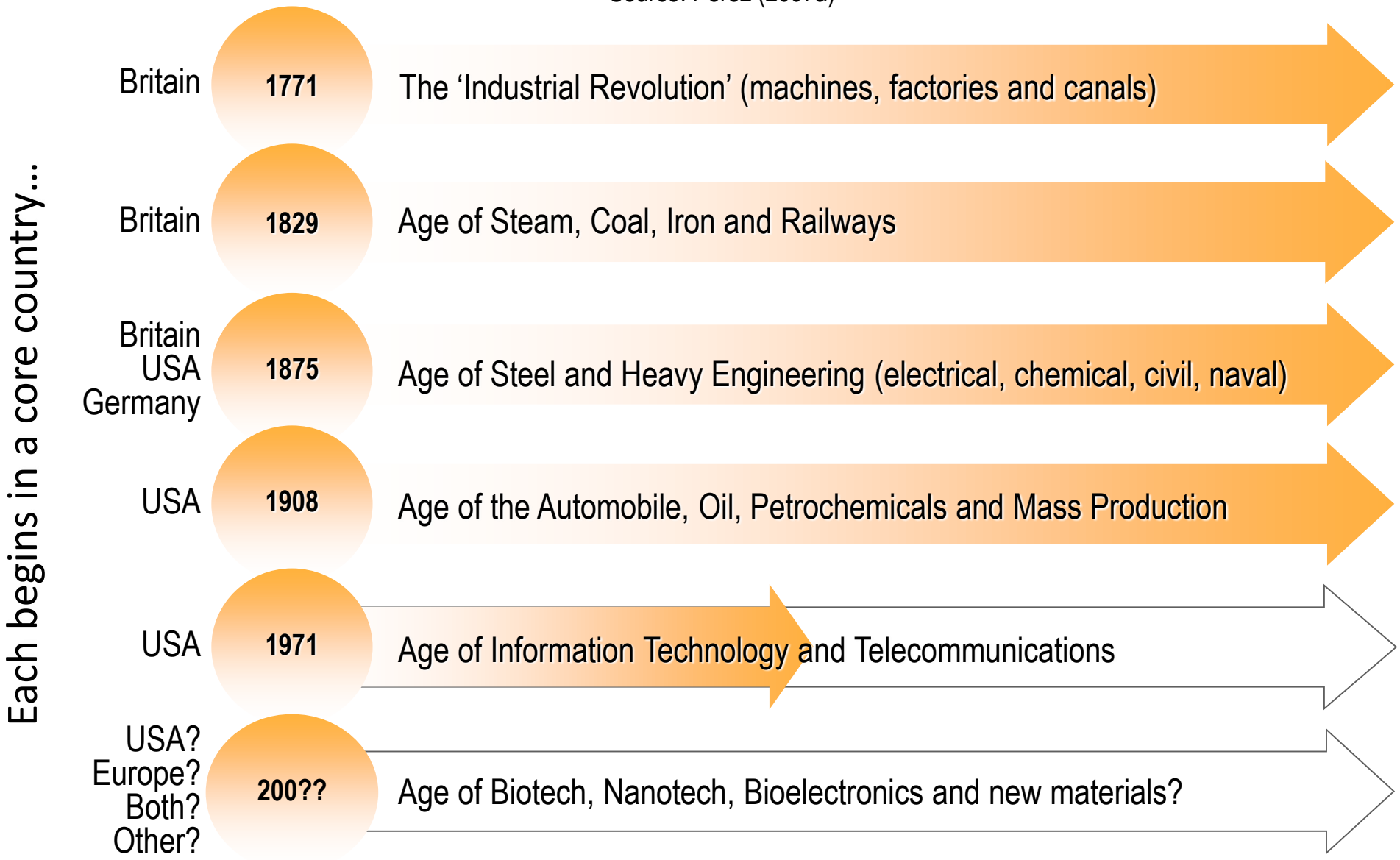
Change of techno-economic paradigm

- 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 behavior.

Freeman and Perez (1988)

FIVE TECHNOLOGICAL REVOLUTIONS IN 200 YEARS

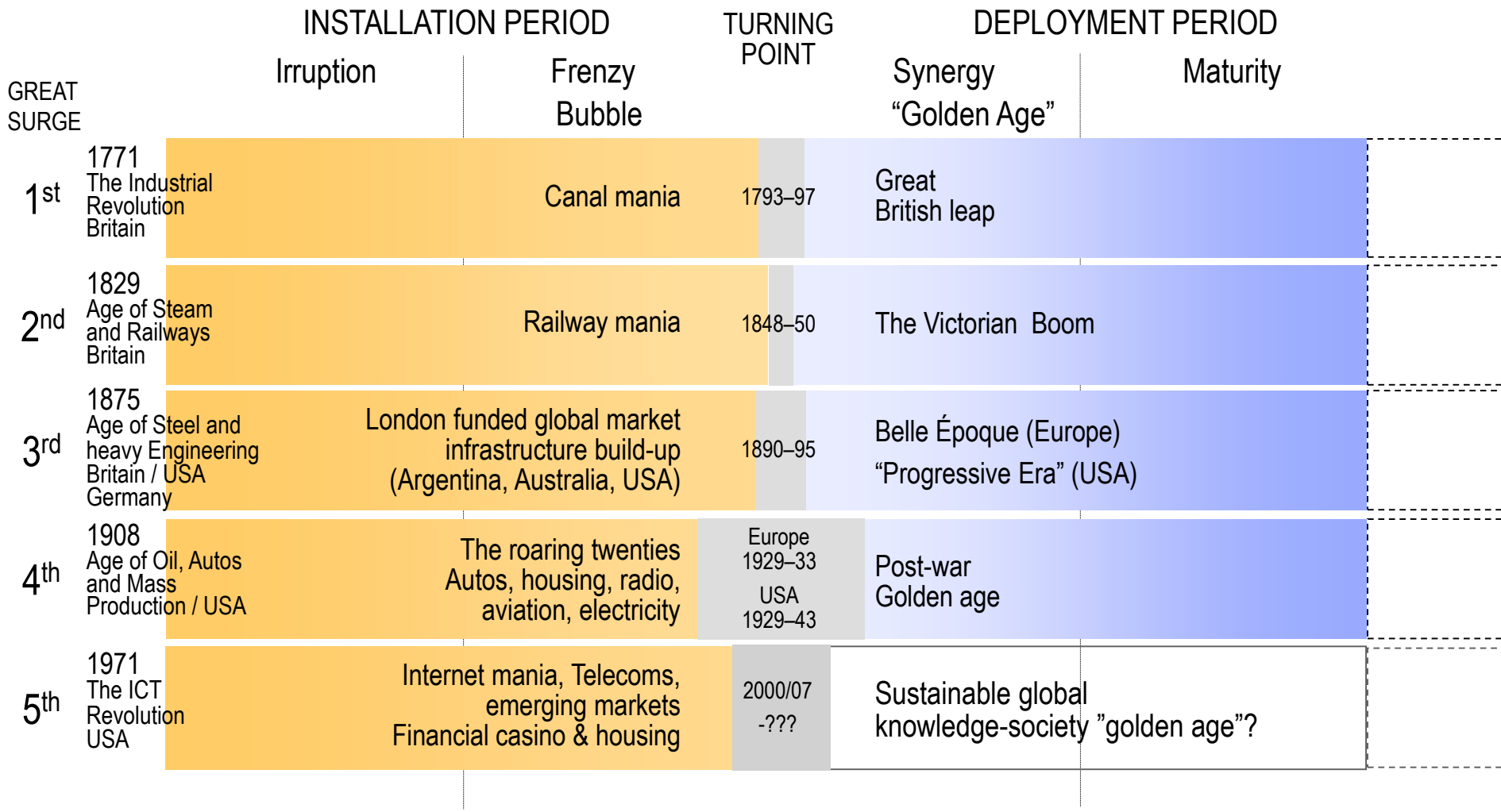
Source: Perez (2007a)



...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

Source: Perez (2007a)

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")

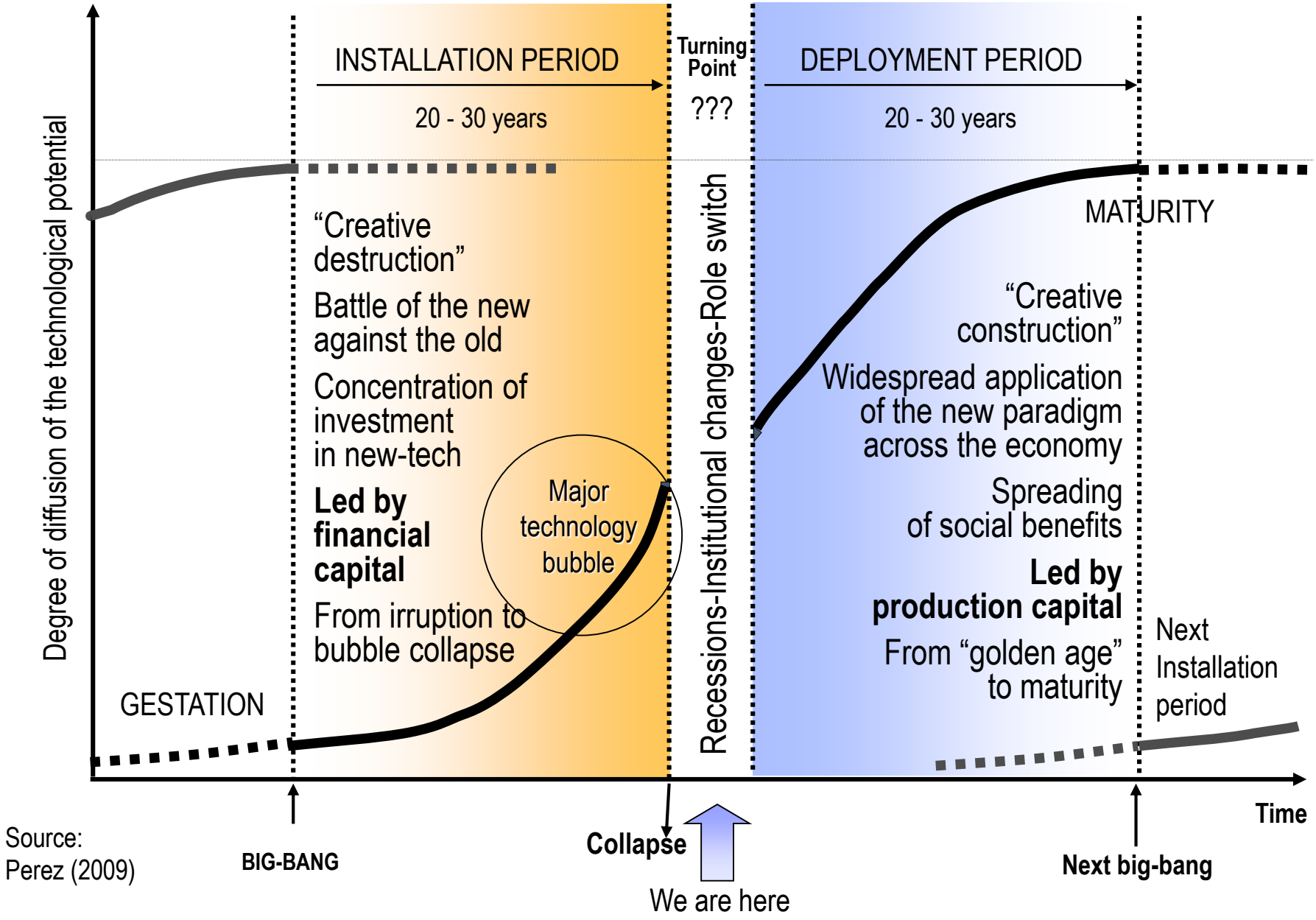
UNIQUENESS

- 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

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

EACH GREAT SURGE IS BROKEN INTO TWO DIFFERENT PERIODS



Source:
Perez (2009)

Technology

- Different from science
- Not just information, knowledge intensive
- Tangible and intangible
- Aspects of technology
    - Embodied (in equipment tangible and intangible)
    - Codified (information in books, manuals, plans etc.) and tacit (knowledge)
    - Empirical (art)
    - Organizational dimension: operational mode, routines, perceptions, culture
- Endogenous
- Know-how, know-what and know-why
- Firm (organization) -specific

Information and knowledge

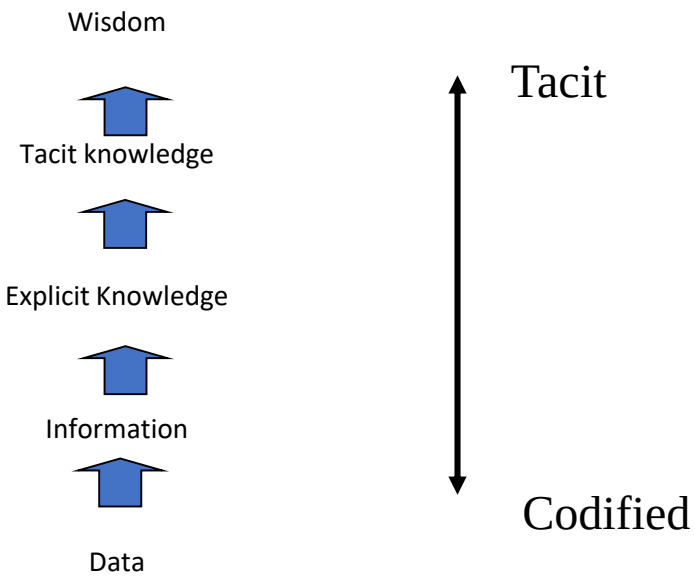
"Knowledge –in whatever field- empowers its possessors with the capacity for intellectual or physical action. What I mean by knowledge is fundamentally a matter of cognitive capability. Information, on the other hand, takes the shape of structured and formatted data that remain passive and inert until used by those with the knowledge needed to interpret and process them"

(Foray, 2004, p.4)

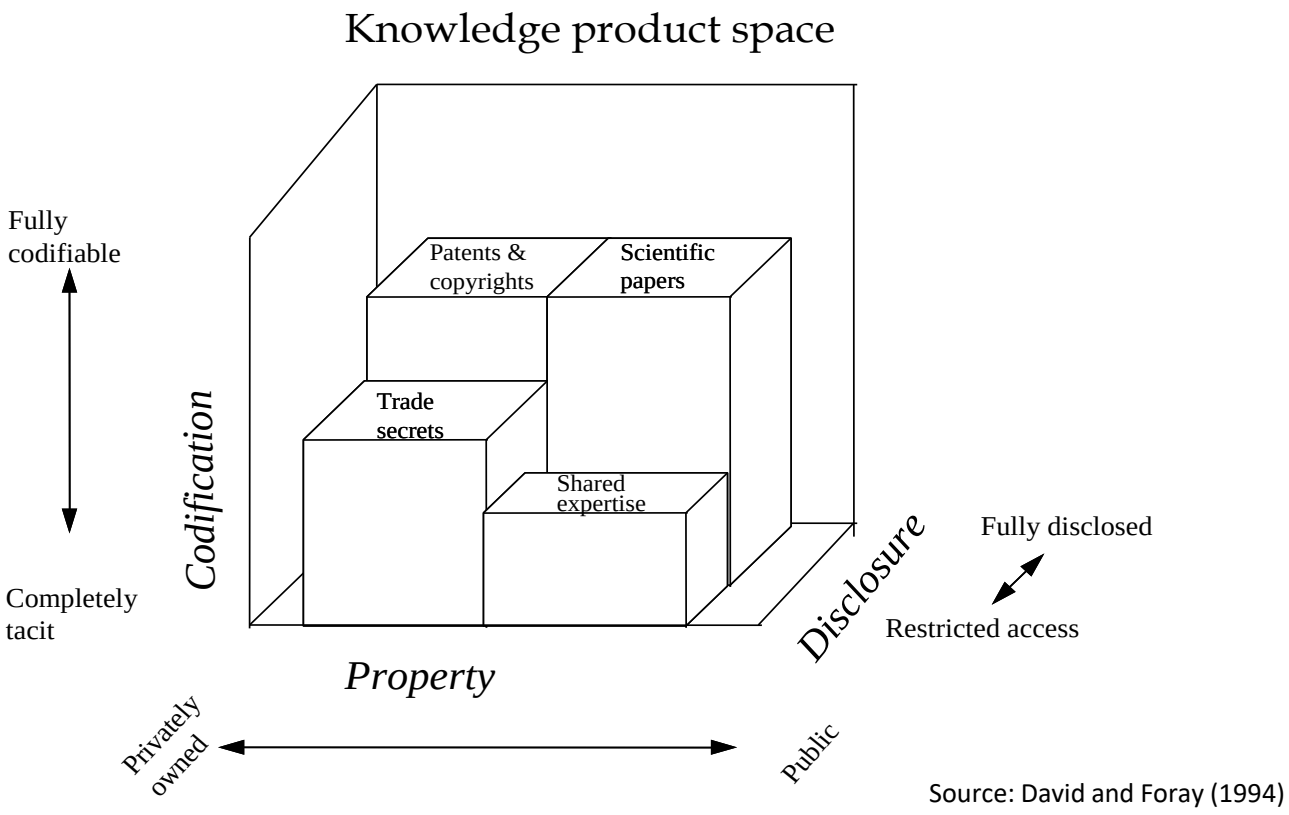
- Knowledge is the cumulative result learning (processes)
- Knowledge different from information
  - Information "represents the sum total of 'messages'"
  - Information is marketable, i.e. exchangeable, transferable
  - Knowledge is not marketable
  - Knowledge is embodied in individuals, organizations, processes

Information to tacit knowledge

According to the degree of codification:



Knowledge and Technology



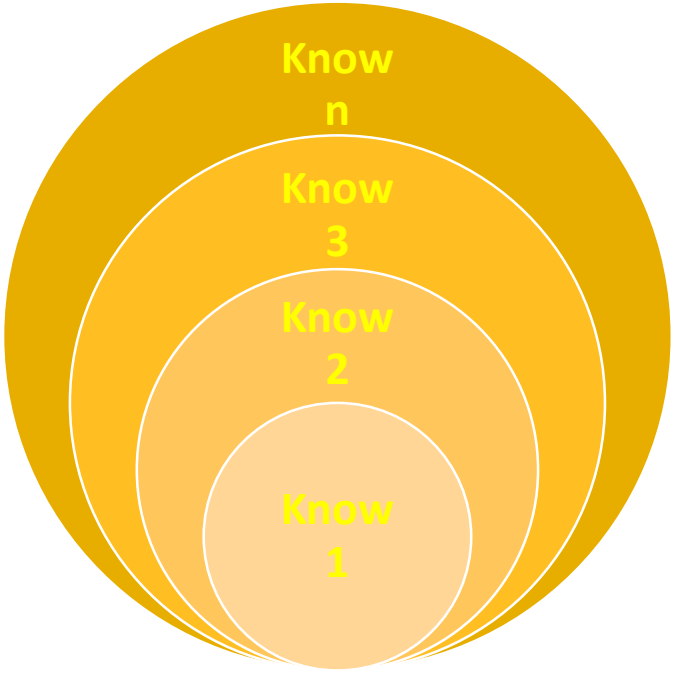
Source: David and Foray (1994)

LEARNING

- Learning occurs in organizational settings (e.g. groups, teams, firms, networks, clusters, regions/states)
- Learning is institutionalized
- Learning processes are usually associated with specific contexts and locations
  - Industries, technologies, geographies
- Learning-by-doing
  - "takes place at the manufacturing (and/or utilization) stage after the product has been designed" (Foray, 2004, p. 58)
- Learning-by-using
  - "using generates problems; problem-solving capacities are deployed and learning occurs" (Foray, 2004, p. 62)
- Communities of practice:
  - Learning not only situated but with a social character (Lave and Wenger, 1991, p.122)

Knowledge and learning

- Knowing, not knowing, learning



- absorptive capacity

IPRs (Intellectual Property Rights)

are considered to serve three functions in relation to the formation of knowledge commons:

- to hinder
- to assist
- to have no relation to knowledge commons

Innovation is a network phenomenon

"Emerging technologies are not developed and commercialized by individuals or single firms. They are developed by networks."

Rosenkopf (2000, p. 337)

Networks of …?

- Intended and emergent (unintended) k-networks in
  - Alliances
  - “cooperative technical organizations” (professional societies, trade associations, standards bodies, technical communities etc.)
  - Joint authorship
  - “Board interlocks”
  - “Job changers”
  - Electronic communication

Rosenkopf (2000, pp. 344-6)

"Understanding Knowledge as Commons"?

- "we use the terms *knowledge commons* and *information commons* interchangeably"
  - "all intelligible ideas, information, and data in whatever form in which it is expressed or obtained"
  - "all types of understanding gained through experience or study, whether indigenous, scientific, scholarly, or otherwise nonacademic"

(Hess and Ostrom, 2007, p. 7-9)

- "the tragedy of the anticommons in the knowledge arena lies in the potential underuse of scarce scientific resources caused by excessive intellectual property rights and overpatenting in biomedical research"

(ibib, p. 11, from Heller 1998)

- ***enclosure of knowledge products (information), not knowledge itself***

		SUBTRACTABILITY	
		Low	*High*
EXCLUSION	*Difficult*	**Public goods** Useful knowledge Sunsets	**Common-pool resources** Libraries Irrigation systems
	Easy	**Toll or club goods** Journal subscriptions Day-care centers	**Private goods** Personal computers Doughnuts

(Hess and Ostrom, 2008; p. 9)

Understanding knowledge as commons?

Club

"a group sharing a particular type of impure public good, characterized by congestion and *excludable benefits"*

(Buchanan, 1965; Cornes and Sandler 1996; p. 4)

"… diverse definitions for clubs have been stated, depending upon what was being shared"

[a taste for association, cost reductions from scale economies, cost reductions from team production, public goods, public factors]

(Sandler and Tschirhart, 1980)

Theory of clubs: mainstream origin?

"… provides the theoretical foundation for the study of allocative efficiency for an important class of impure public goods" (Cornes and Sandler 1996; p. 12)

	Non-excludability of benefits	**Excludability of benefits**
Non-rivalry of use, indivisibility of benefits	Pure public good	Impure public good – Club good

"Gradually, the list of impure public goods expanded to include, among others, recreation areas, schools, highways, communication systems, information networks, national parks, waterways, and the electromagnetic spectrum." (ibid, p. 4)

Knowledge is - ontologically - a club good

- Easy to exclude:
- Exclusion mechanism:

  barriers to learning (tacit, conjectural knowledge, situated learning, proximity)

- Inclusion mechanism:

  Toll: the cost of learning

  Learning as **initiation**: “absorbing and being absorbed in - the "culture of practice“.” (Lave and Wenger 1991, p. 95)

- Heterogeneous membership:
  - “peripheral participation”

- non-rival
- tacit and explicit
- excludable
- cumulative
- localized – contextual - situational
- sticky
- dispersed
- organizational
- embedded
- transaction specific asset
- asymmetric
- political

Knowledge-based approach

"*organizations are* ***social communities in which individual and social expertise is transformed into economically useful products and services by the application of a set of higher-order organizing principles****. Firms exist because they provide a social community of voluntaristic action structured by organizing principles that are not reducible to individuals*"

"*a firm's functional knowledge is nested within a higher-order set of recipes that act as organizing principles. Complex organizations exist as communities within which varieties of functional expertise can be* ***communicated and combined by a common language and organizing principles***"

Kogut and Zander (1992)

Communities of practice

"groups of **people** who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis"

(Wenger et al., 2002, p. 4)

- **Participation** a prerequisite of learning and knowledge
- Learning as legitimate peripheral participation
- **Meaning**, "cognition and communication in, and with, the social world are situated in the historical development of ongoing activity."
- "knowing as activity by specific people in specific circumstances"

(Lave and Wenger 1991, p. 50-52)

Passive vs Dynamic clubs

Participation

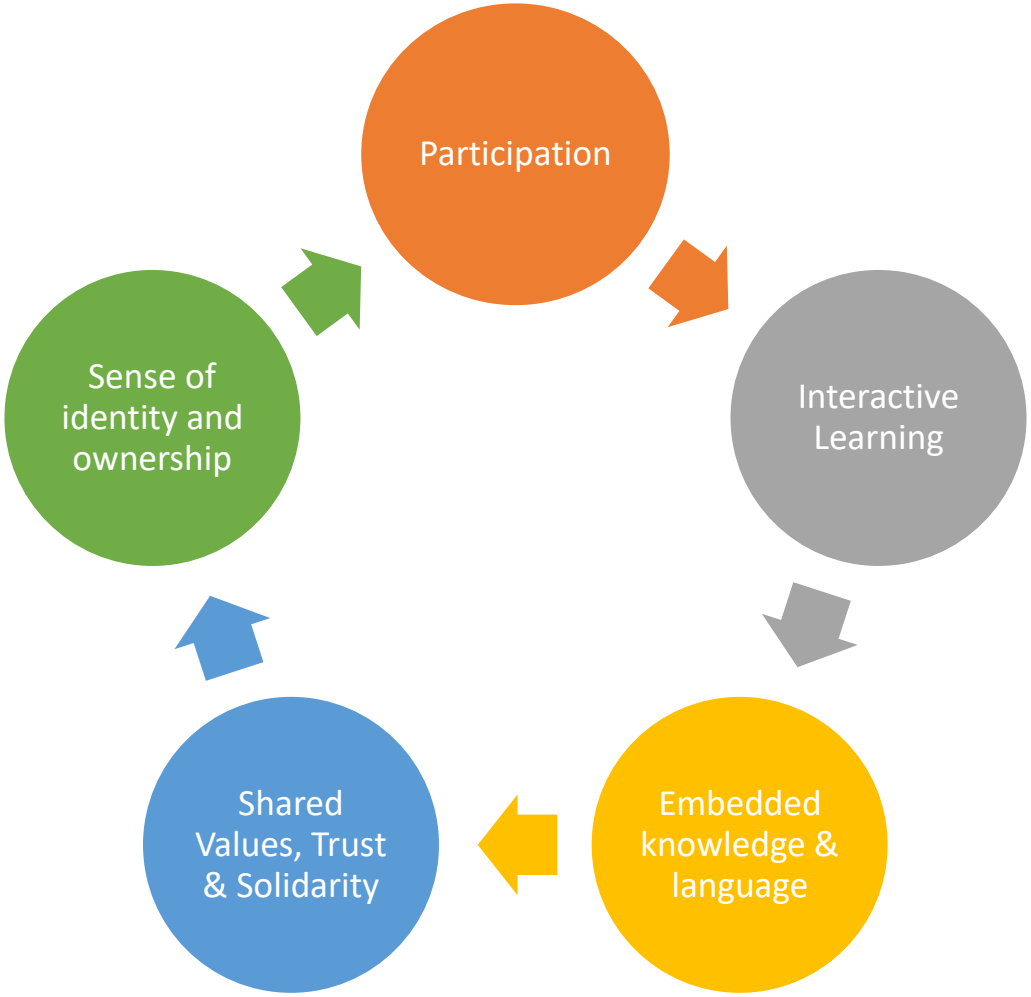
- **Passive**: members enjoy the benefits without active involvement (passive use/consumption)
- **Active**: members involvement enhances efficiency and effectiveness, hence benefits (e.g. unions, knowledge)

(Reverse) tragedy of the club - not free riders, but collective *in*action

- Use of knowledge induces participatory learning, hence knowledge accumulation (reinforcing feedback loop)

Increasing returns

Active membership club dynamics



National System of Innovation

"the network of institutions in the public and private sectors whose activities and interactions initiate, import and diffuse new technologies" (Freeman, 1987)

- R&D organizations are "embedded in a much wider socio-economic system in which political and cultural influences as well as economic policies help to determine the scale direction and relative success of all innovative activities" (Freeeman, 2002)
- "… all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations" (Edquist, 1997)

Two major early studies

- Lundvall (1992) interactive learning, user-producer interactions
  - Two dimensions
    - Structure of production
    - Institutional set-up
- Nelson (1993) nations' R&D systems
  - Organizations that promote the creation and dissemination of knowledge
- Each approach single out different factors reflecting their assumptions on the significance as determinants of innovation activities

Formal Organizations in ISs

- “formal structures that are consiously created and have an explicit purpose” (Edquist, 2005)
- They are players, actors, agents, stakeholders
  - firms,
  - universities,
  - Research Institutes
  - Corporate R&D facilities
  - VC,
  - public policy agencies (addressing innovation, education, competition, environment etc.)
  - unions
- Organizational set-up varies considerably, it is ‘system specific’

Institutions

- “sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups, and organizations” (Edquist 2005)
- Great variance between countries and regions
  - e.g. culture, professional rules, patent laws, rights to university research etc.

Functions in ISs

- Various views depending on the level of analysis, the focus of analysis (firms, policy, public organizations etc.)
- Edquist (2005) suggests an "overall function" in ISs:
  - "to pursue innovation processes, i.e. develop, diffuse and use innovations"
  - all 'individual' functions or sub-functions serve this generic purpose
- We may distinguish in main and supporting functions
  - Main those that directly pursue innovation
  - Supportive those that seek to enable innovation: e.g. creation of human capital, facilitate interaction or financing

Activities in ISs

- Edquist suggests a provisional list of activities that serve various functions, but he mostly describes the functions served e.g.:
  - R&D – knowledge creation
  - Education and training – competence building (individual)
  - Formation of new product markets
  - Articulation of quality requirements
  - Networking
  - Creating and changing organizations
  - Creating and changing institutions etc
- Many activities may be carried out by a variety of organizations or inter-organizationally

Interaction in ISs

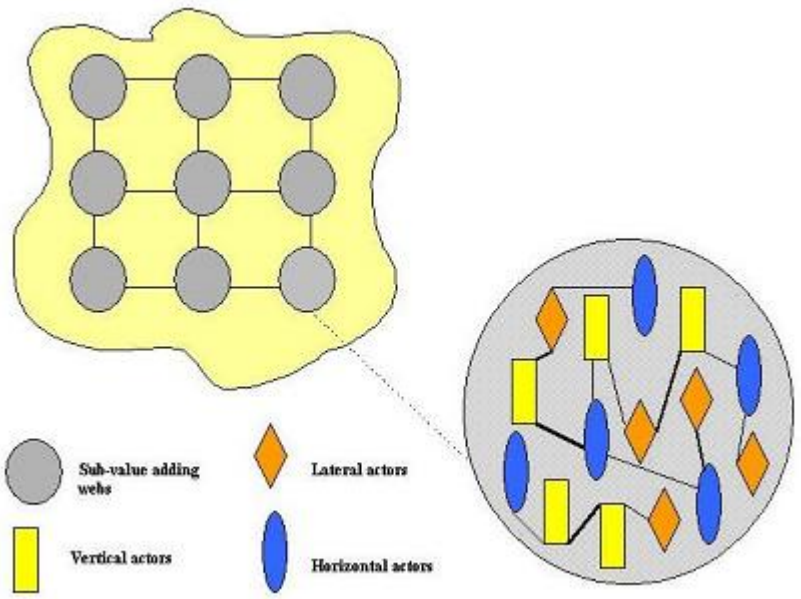
- Institutions influence or govern the set-up of activities and the interaction of actors performing these activities
- Interaction may be market or non-market (OECD 2002)
  - Competition
  - Transaction
  - Co-operation
- Interactive learning

CLUSTERS

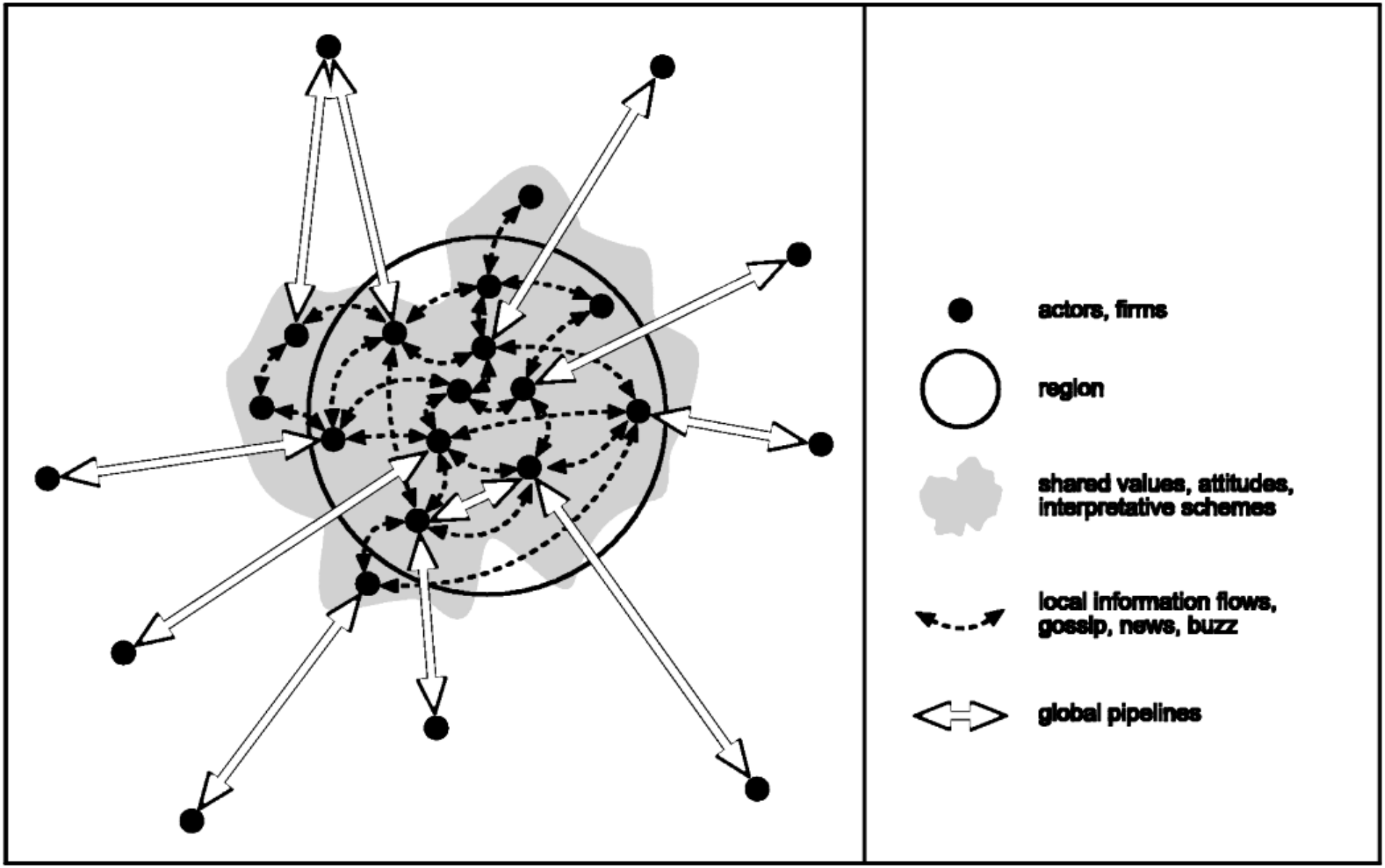
"A geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities"

(Porter, 2000, p.16)

"A cluster is a connection of horizontal, vertical and lateral **value adding activities** contributed by different actors in proximity to one another which all act in relation to a specific industry. Together the actors are building a value adding web which defines the boundaries of the cluster. Direct and indirect interactions take place between these actors which may be reflected in strong, medium or weak links."
(Brown et al. 2007)



The structure and dynamics of local buzz and global pipelines



Source: Bathelt et al., 2004, p. 46

Socio-technical systems

- Socio-technical systems are thought as ensembles of technologies, artefacts, technology development and use/consumption processes, groups of scientists, users, etc. that address specific societal functions. Innovations that change the structure and behaviour of such ensembles are referred to as system innovations, or socio-technical system transitions.

(Geels, 2018)

- Socio-technical systems are actively created, (re)produced and refined by several social groups, for instance, firms, universities and knowledge institutes, public authorities, public interest groups and users. Their activities reproduce the elements and linkages in socio-technical systems. These social groups have their own vested interests, problem perceptions, values, preferences, strategies and resources (money, knowledge and contacts).

(Geels, 2005)

- A socio-technical system (STS) consists of two co-evolving subsystems: the development and production of technological artefacts subsystem and the technology and artefacts use subsystem.

(Adamides & Mouzakitis, 2009)

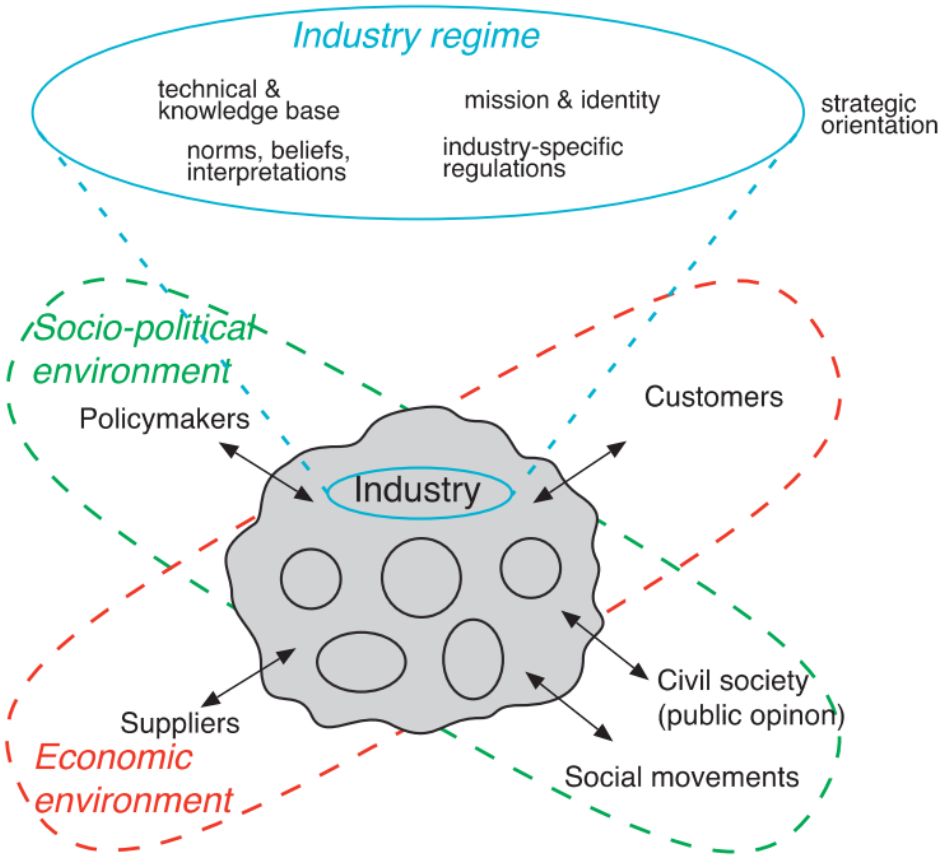


Fig. 2. Triple embeddedness framework of industries.
Source: (adapted from Geels, submitted for publication).

(Turnheim and Geels, 2012)

Why there is stability?

Industry regimes are usually stable, because of various lock-in mechanisms and commitments:

1) **Commitment to cultural-cognitive institutions** (mental maps, beliefs) focuses the interpretations of actors, blinding them to developments outside their focus. Cognitive inertia may lead to mis-interpretation of external threats and delays in response strategies.

2) **Commitment to mission and identity** refrains industry actors from changing their strategic and societal positioning.

3) **Commitment to the existing technical competencies** creates resistance against technological discontinuities.

4) Industry actors are **committed to industry-specific regulatory institutions** through compliance mechanisms. These institutions constrain the behavior of industries with incentives and disincentives.

(Turnheim and Geels, 2012)

Socio-technical transition

Socio-technical transition is multi-dimensional, i.e. it encompasses technological as well as organizational, institutional and socio-cultural change.

In the course of a transition, new products, services, business models, organizations, regulations, norms and user practices emerge, partly complementing but more often substituting existing ones.

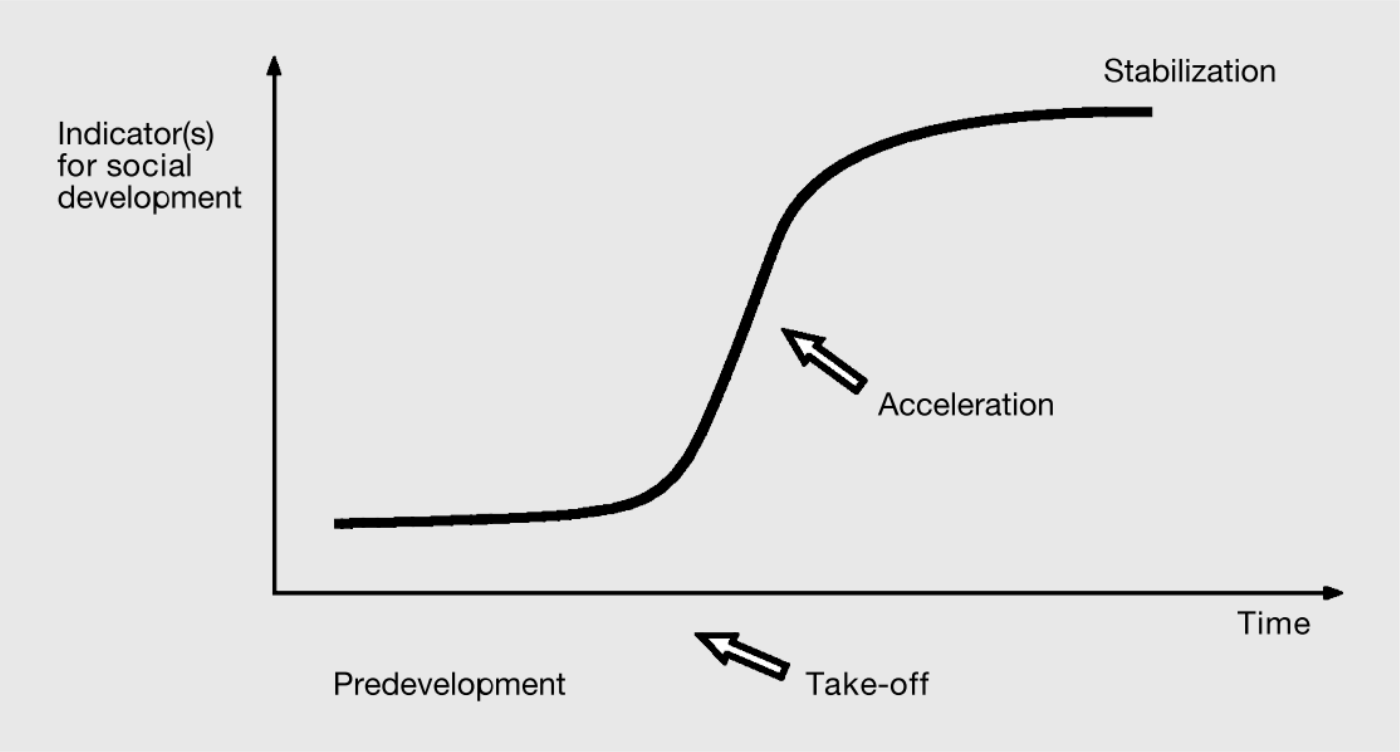
A socio-technical transition is commonly understood as a fundamental transformation of a socio-technical system.

(Markard et al., 2016)

Transitions are multi-actor processes that involve interactions between many social groups, e.g. commercial transactions, political negotiations, power struggles and creation of coalitions.

(Geels, 2005)

4 Transition phases



- A predevelopment phase of dynamic equilibrium where the status quo does not visibly change.
- A take-off phase where the process of change gets under way because the state of the system begins to shift.
- A breakthrough or acceleration phase where visible structural changes take place through an accumulation of socio-cultural, economic, ecological and institutional changes that react to each other. During the acceleration phase, there are collective learning processes, diffusion and embedding processes.
- A stabilization phase where the speed of social processes, diffusion and embedding processes.

(Rotmans et al., 2001)

Destabilization

- **The (neo-Schumpeterian) innovation studies literature** proposes that destabilisation is caused by '**disruptive' innovations**, which lead to the decline of existing industries and undermine the resource base of existing regimes.

- **Scholars in industrial economics and economic history** propose that destabilisation is caused by other **economic factors such as shrinking markets, changing markets, and new entrants** that outcompete the focal industry (e.g., because of lower costs or more efficient process technologies).

- **Institutional theorists** see destabilisation as a **de-legitimisation process**. The core mechanism is that a loss of political or cultural legitimacy weakens the support from important stakeholders (policy makers, wider publics).

- **Management and organisational scholars** propose **'inside-out' views** that address the enactment of destabilisation from a **firm-oriented perspective**.

(Turnheim and Geels, 2012)

Forces leading to transition

1. Formation forces: related to the potential for societal innovation.
2. Support forces: strengthen or weaken present transitional trends.
3. Triggers or triggering forces: perturb or shock the system.

- Formation forces include the presence of a niche, the presence of new demand and the presence or appearance of a new functioning.

- Supportive forces include the standardization of practices and routines, the provision of resources and the exercise of power over the regime or novelty by external or internal centres of power.

- Triggering forces include crises, systemic failures and exogenous events.

(Frantzeskaki and De Haan, 2009)

While destabilization…

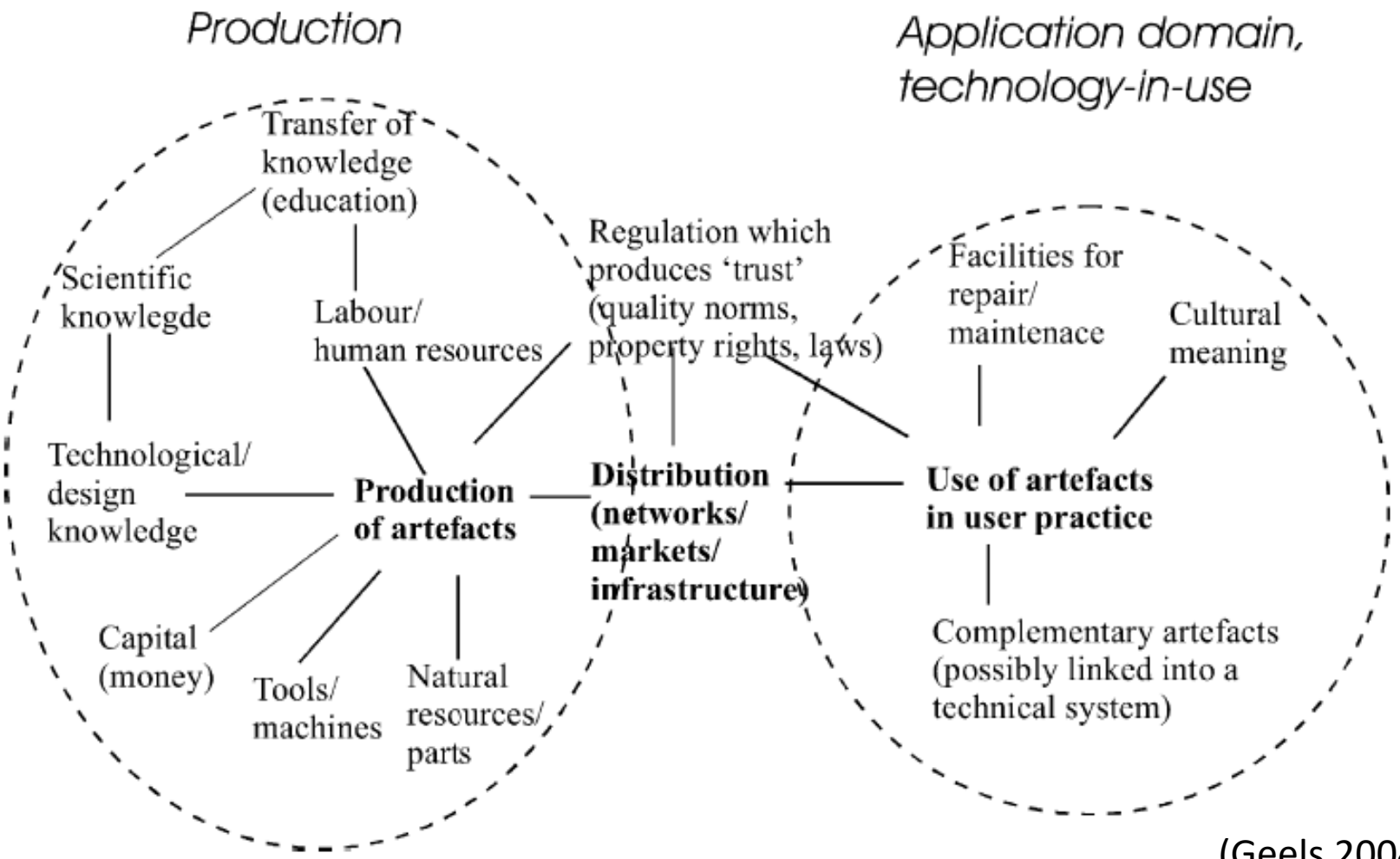
- external pressures and endogenous enactment co-evolve with each other,
- increasing external pressures weaken the performance of industries (both in terms of financial resources and socio-political legitimacy).
- major policy change is often important in destabilisation, because it shapes both the direct support for industries (e.g., subsidies) and economic frame conditions (taxes, import restrictions, regulations).
- **Public opinion and discourse is important,** because it, first, influences the cultural legitimacy of industries.

(Turnheim and Geels, 2012)

Transition: How do we go from this

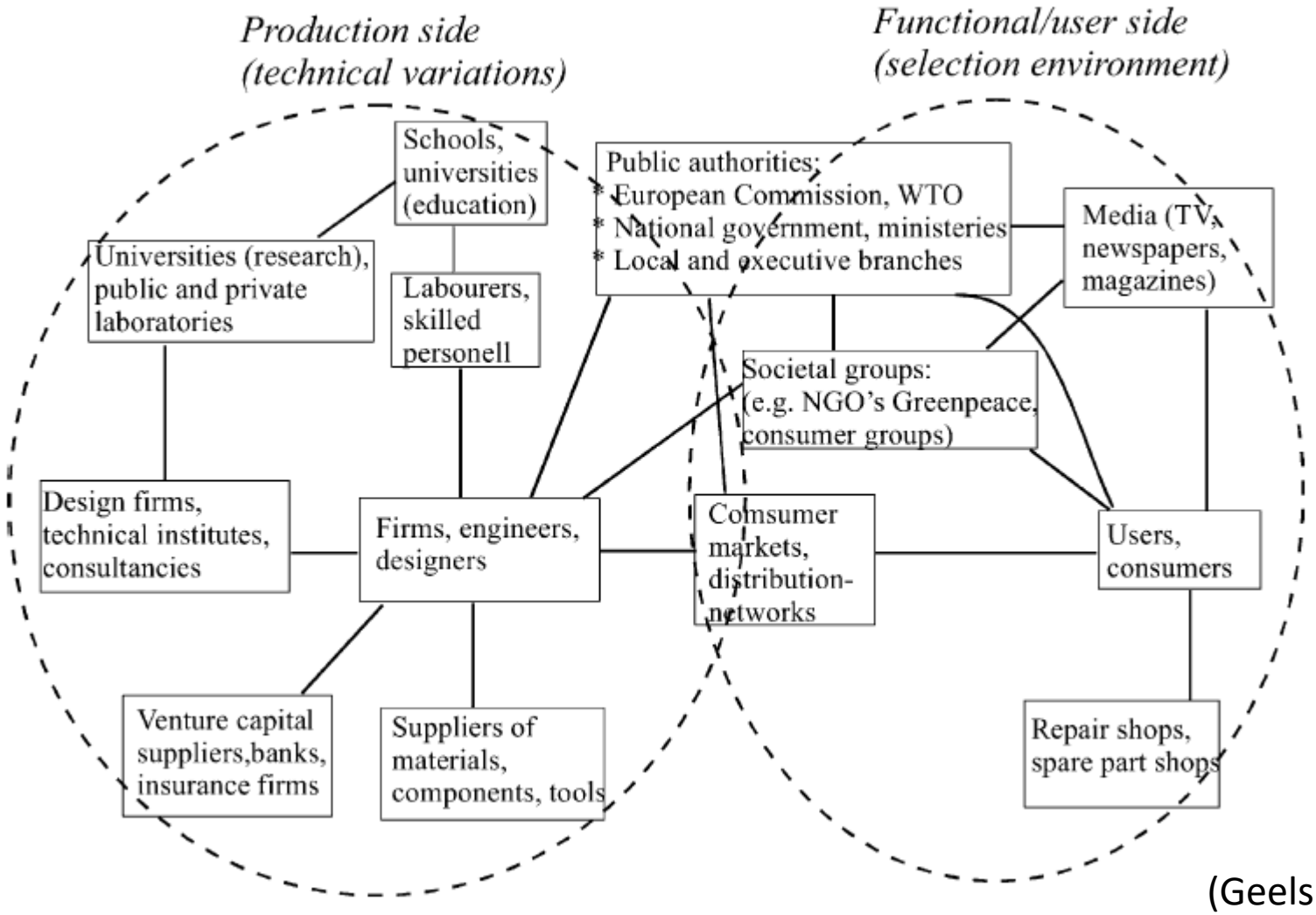
to THIS?

The basic elements and resources of socio-technical systems



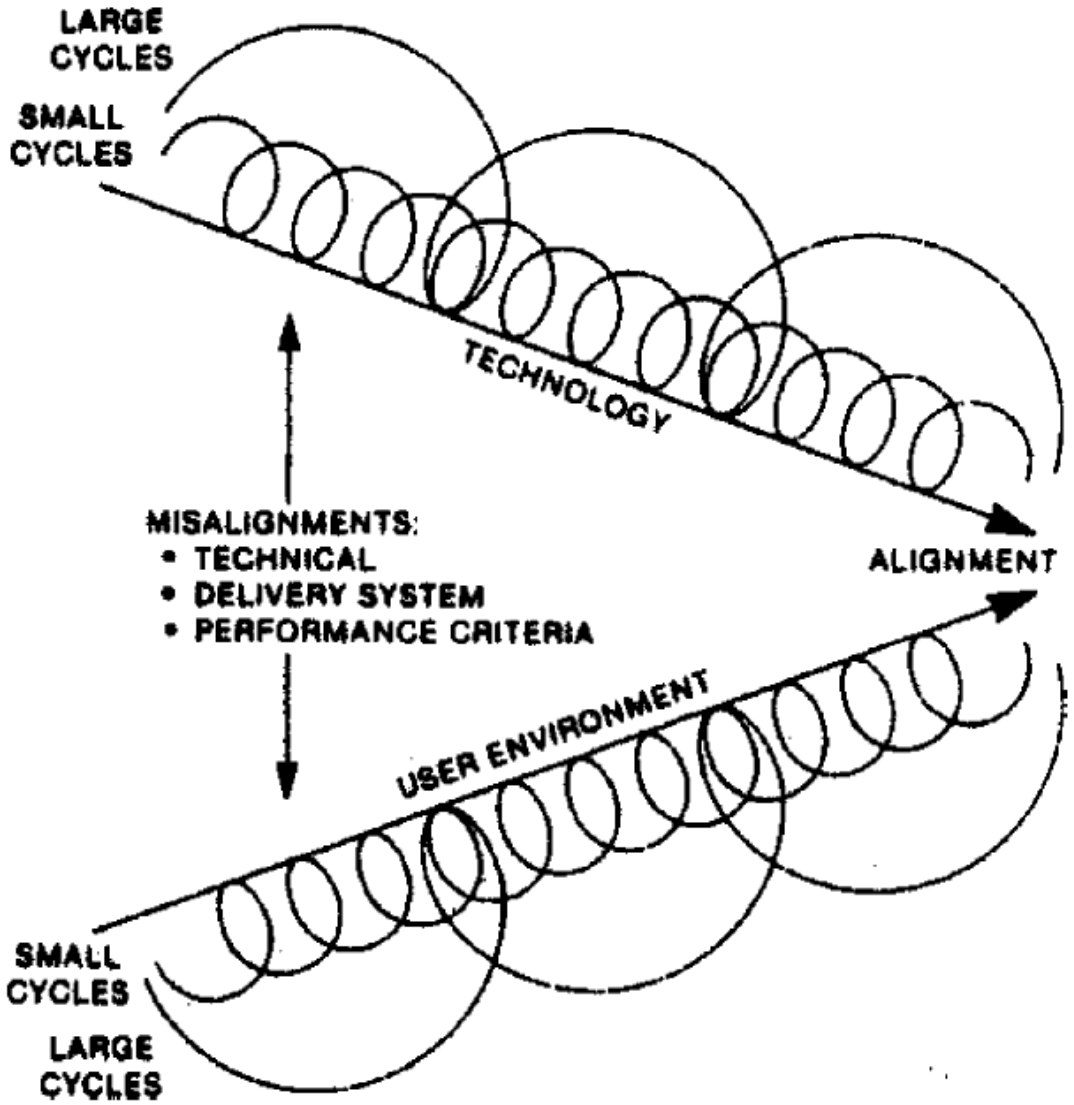
(Geels 2004)

Social groups which carry and reproduce ST-systems



(Geels 2004)

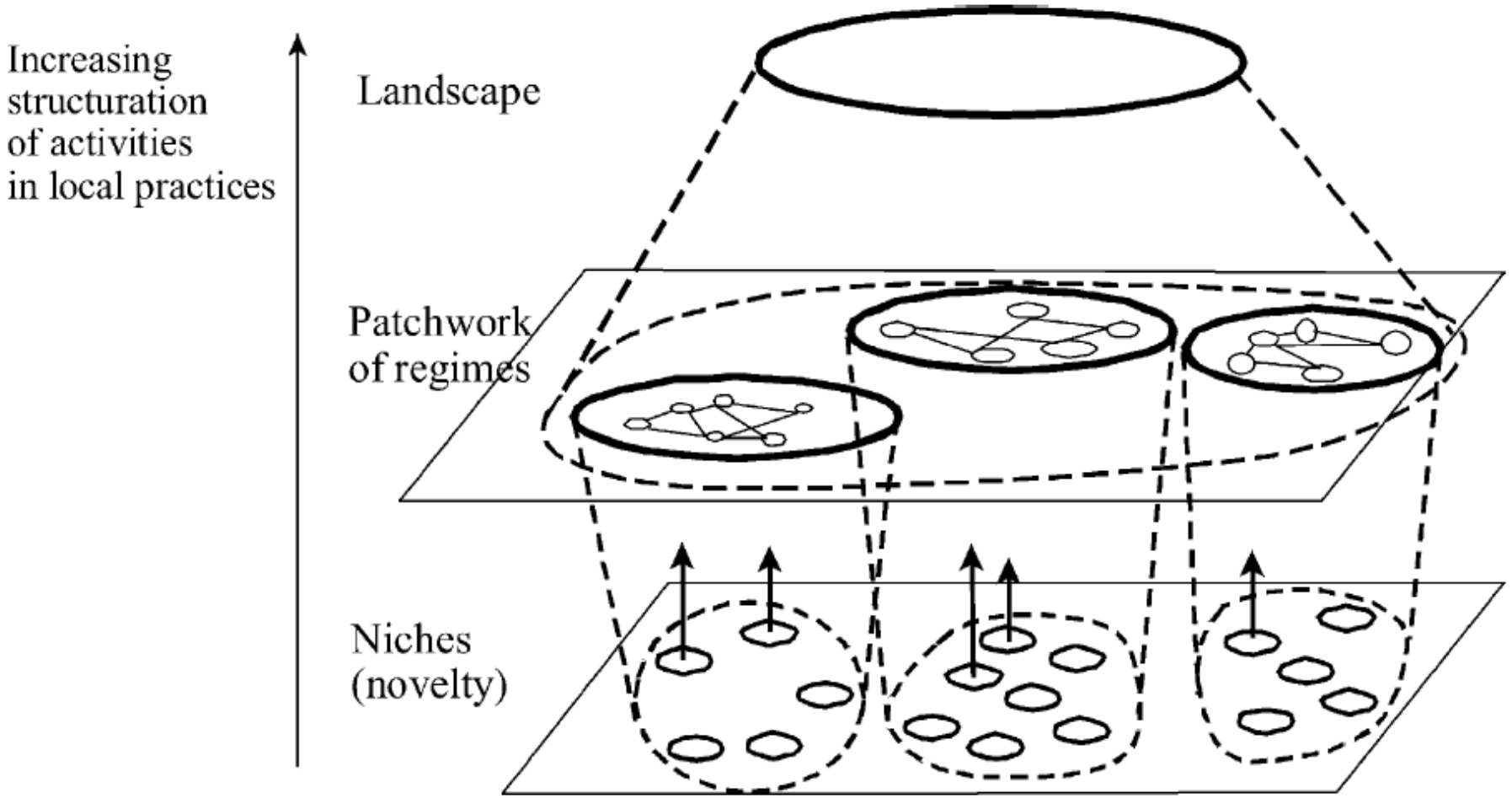
Co-evolution of technology and user environment (Leonard-Barton, 1988, p. 2



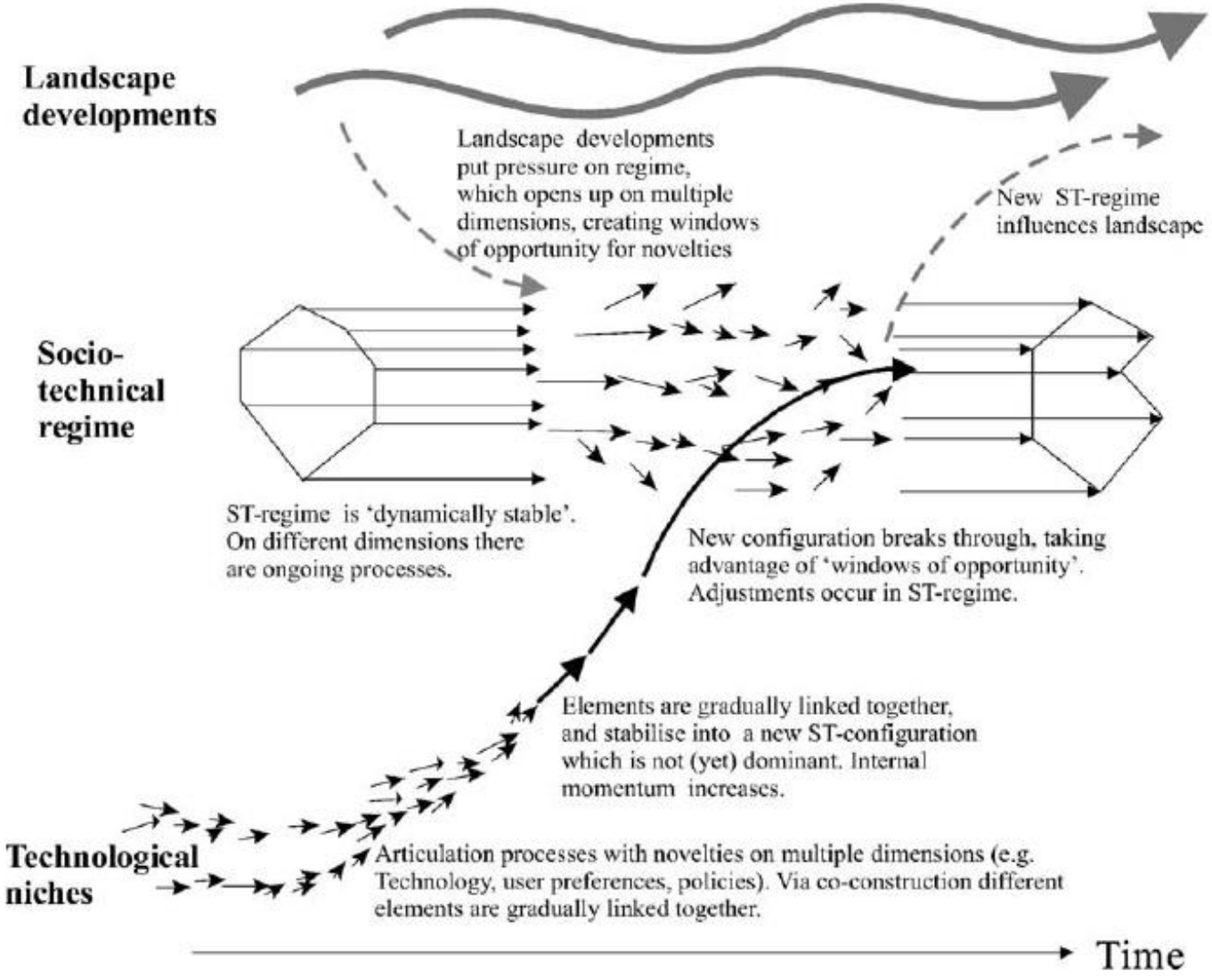
The emergence of radical innovations in niches

- ‘protected spaces’ as ‘incubation rooms’ shielding them from mainstream market selection.
  - subsidies, by public authorities
  - strategic investments within companies (‘skunk works’),
  - small market niches with specific (high-performance) selection criteria
  - technological niches (experiments in the 1990s with electric vehicles in various European countries and cities)
- they provide locations for learning processes – ‘platforms for interaction’
  - “Apart from demonstrating the viability of a new technology and providing financial means for further development, niches helped to build a constituency behind a new technology, and to set in motion interactive learning processes and institutional adaptations-in management, organization and the institutional context-that are all-important for the wider diffusion and development of the new technology.” (Kemp, Schot and Hoogma 1998)
- they allow to deviate from the rules in the existing regime

Multiple levels as a nested hierarchy (Geels, 2002a)



A dynamic multi-level perspective on system innovations (Geels, 2002b, p. 1



Strategic Niche Management

- "… is the creation, development and controlled phase-out of protected spaces for the development and use of promising technologies by means of experimentation, with the aim of
  - (1) learning about the desirability of the new technology and
  - (2) enhancing the further development and the rate of application of the new technology" (J. Schot et al. 1994)

Literature

- Bathelt, H., Malmberg, A. and Maskell, P. (2004) “Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation”. *Progress in Human Geography*, 28 (1), pp. 31-56
- **Cohen W.M. and Levinthal D.A. (1990) Absorptive Capacity: A New Perspective on Learning and Innovation, Administrative Science Quarterly, Vol. 35, No. 1, Special Issue: Technology, Organizations, and Innovation pp. 128-152**
- Edquist, C. (2005) “Systems of Innovation Perspectives and Challenges”, in Fagerberg J. et al. (eds) The Oxford Handbook of Innovation, Oxford University Press, Oxford, pp. 181-208
- Freeman, C. 1995. The ‘National System of Innovation’ in historical perspective, Cambridge Journal of Economics, vol. 19, 5–24
- Freeman, C. 2002. Continental, national and sub-national innovation systems—complementarity and economic growth, Research Policy, vol. 31, 191–211
- **Freeman and Perez (1998) "Structural Crises of Adjustment: Business Cycles and Investment Behaviour", in Dosi, G. et al. (eds) Technical Change and Economic Theory, London, Pinter, pp. 38-66**
- Hall B.H. (2005) “Innovation and Diffusion”, in Fagerberg J et al. (eds) The Oxford Handbook of Innovation, Oxford University Press, Oxford, pp. 459-484
- Kemp R., Schot J. and Hoogma R. (1998). ‘Regime shifts to sustainability through processes of niche formation: the approach of Strategic Niche Management, *Technology Analysis and Strategic Management*, 10(2). 175-195.
- Perez, C. (2005) “Respecialisation and the deployment of the ICT paradigm: An essay on the present challenges of globalisation” , in Compano et al., 2007, *The Future of the Information Society in Europe: Contributions to the Debate*, Technical Report EUR22353EN, IPTS, Joint Research Centre, Directorate General, European Commission).
- Perez, C. (2009) “Technological revolutions and techno-economic paradigms” , TOC/TUT WP No. 20, Working Papers in Technology Governance and Economic Dynamics The Other Canon Foundation, Norway and Tallinn University of Technology, Tallinn
- **Perez, C. and L. Soete (1988) "Catching up in Technology: Entry Barriers and Windows of Opportunity", in Dosi et al. (eds), pp. 458-479**
- Zurbano, M. (2005) 'Services, networks and territory: The case of MCC in the Basque Country', *The Service Industries Journal*, 25: 4, pp.547 — 561