Innovation and Technology Commercialisation

Week 3: Paths, Positions & Processes

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Key Questions

- What are dynamic capabilities and where do they come from?

- What is learning in relation to innovation? And why is it so important?

Resources and capabilities lead to *Competitive Advantage* when they are:

- **Valuable** — allow the firm to exploit opportunities or neutralize threats in its external env't
- **Rare** — possessed by few, if any, current and potential competitors
- **Costly to Imitate** — when other firms either cannot obtain them or must obtain them at a much higher cost
- **Nonsubstitutable** — the firm must be organized appropriately to obtain the full benefits of the resources in order to realize a competitive advantage

Dynamic Capabilities

- **Position** – Technology, capability, IP, customer links, supplier links
- **Paths** – Strategic alternatives available to the firm.
- **Processes** – Managerial and organizational processes, routines, ways of doing and learning.

Teece & Pisano

Defining Organizational Capabilities

Organizational Capabilities = firm's capacity for undertaking a particular activity. (Grant)

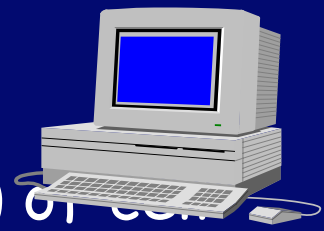
Distinctive Competence = things that an organization does particularly well relative to competitors. (Selznick)

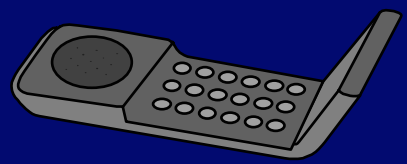
Core Competence = capabilities that are fundamental to a firm's strategy and performance. (Hamel and Prahalad)

Examples: Distinctive Competencies

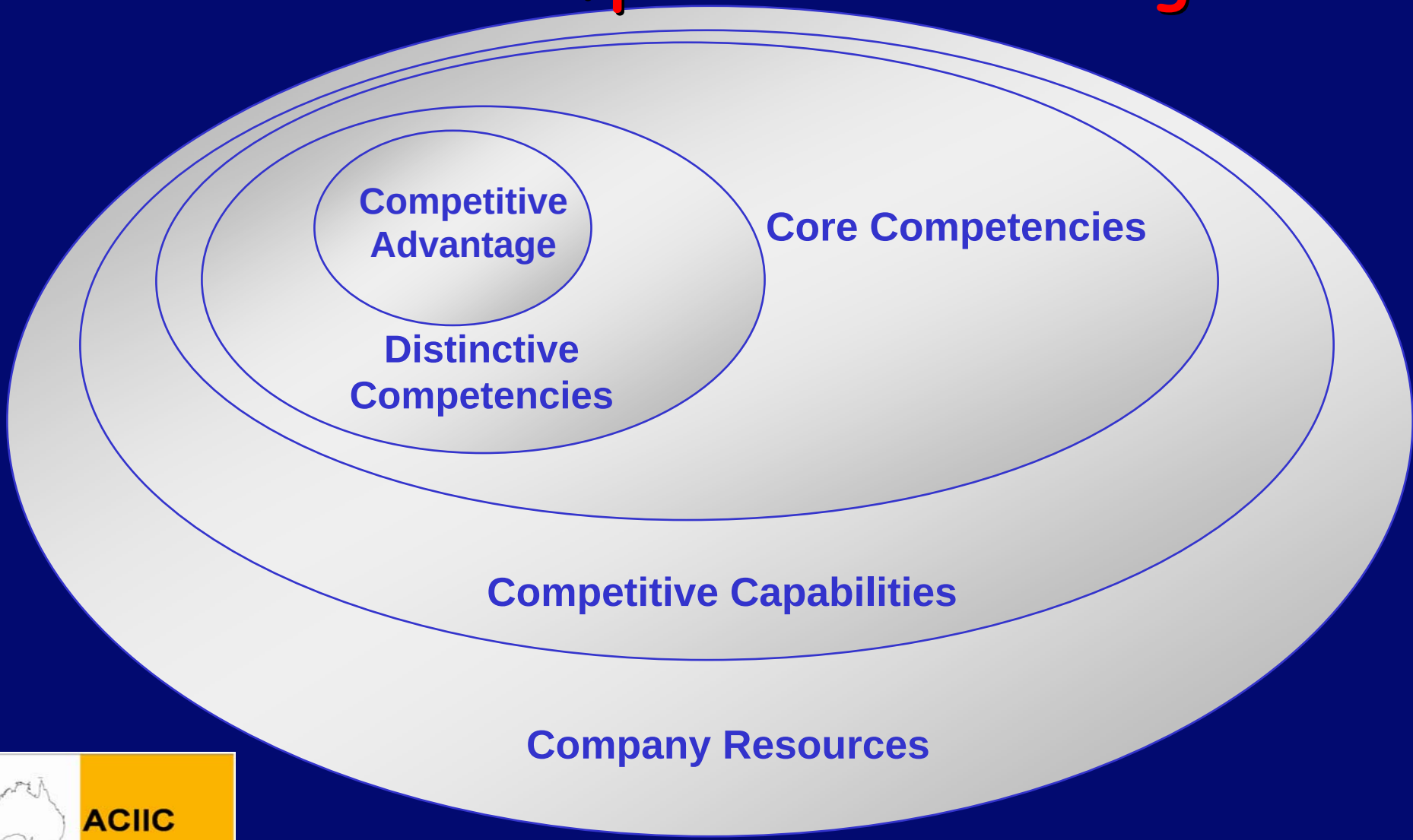
- Sharp Corporation
  - Expertise in flat-panel display technolo
- Toyota, Honda, Nissan
  - Low-cost, high-quality manufacturing capability and short design-to-market cycles

- Intel
  - Ability to design and manufacture ever more powerful microprocessors for PCs
- Motorola
  - Defect-free manufacture (six-sigma quality) of
    phones

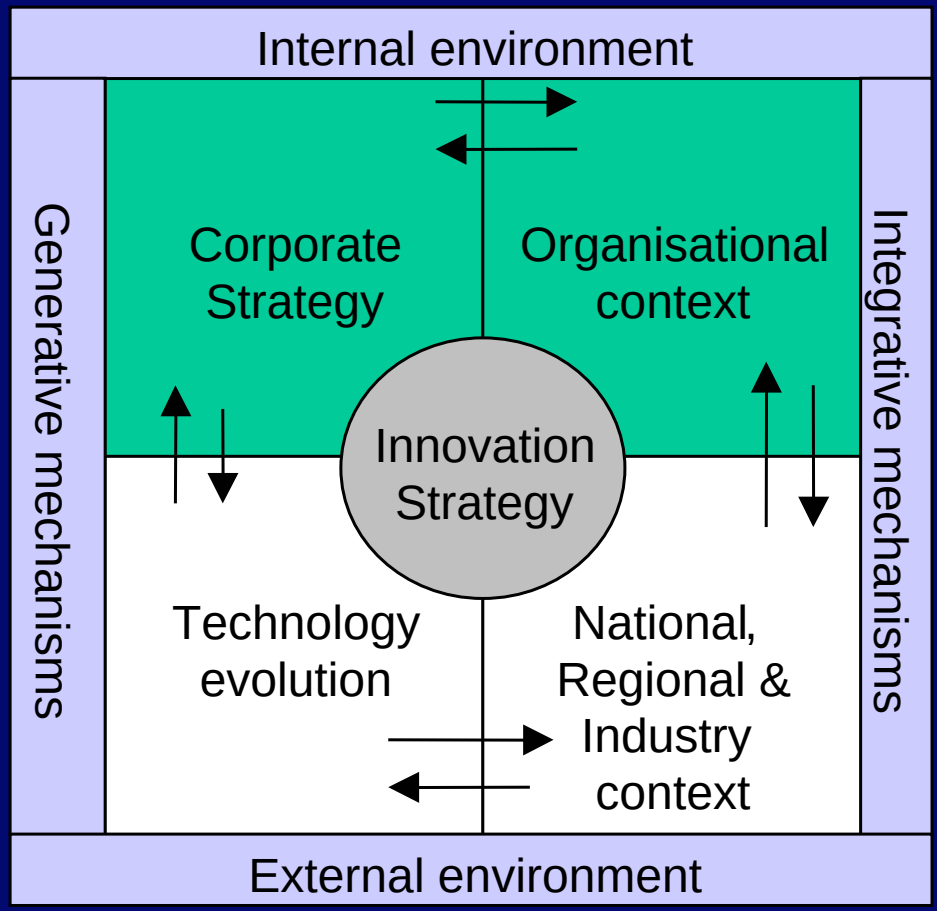




Mobilizing Company Resources to Produce Competitive Advantage



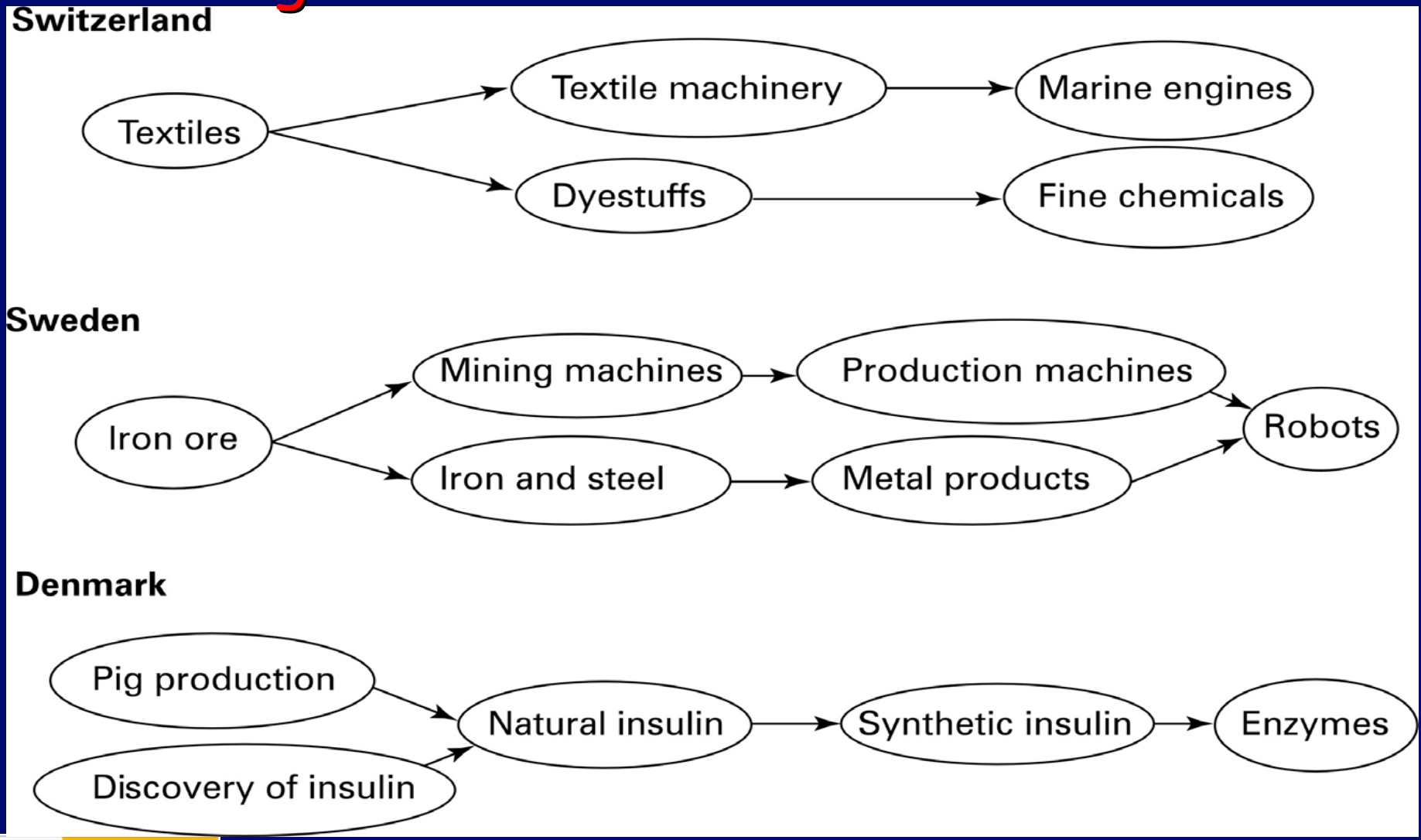
Factors affecting innovation strategy



What Is An Innovation System?

- Set of Nodes in Innovation Chains
- Systemic, Interactive Linkages
- Knowledge Generation Firms & Institutions
- Knowledge Exploitation Firms
- Soft Infrastructure
- Financing
- Commercialisation and Marketing
- Feedback and Policy Support

Technological accumulation in three countries



Innovation Systems

- Acquiring and using knowledge is the core process.
- As firms specialize, due to competition and the deepening knowledge base, there knowledge bases become more widely dispersed and hence more dependent on other firms and organizations.
- Innovators must cross boundaries in the search for new combinations. This causes a pressure for openness, networking and complementarity.
- Knowledge accumulates and leads to increasing returns- innovators investing in knowledge reinforce their learning capabilities.
- Non-market relations like networking reinforce market relations in value chains.

Three sets of interactions

- **Interactions among actors** – firms and organizations. Innovation performance depends on the willingness of firms and organizations to share knowledge.
  - Competition
  - Transaction – trade in goods and services, including knowledge
  - Networking – process through which knowledge is transferred through collaboration, cooperation etc.

- **Interactions among labour, product and capital markets**. High levels of inter-dependence and interaction and these influence knowledge flows and incentives.

- **Interactions between market and non-market mechanisms**, hence the scope of policy covers both the functioning of markets and the stimulation of knowledge flows through networking and collaboration.

Factors affecting NSI

- Cumulative technolgical bases
- Learning
- Workers skills, Education
- Government policy
- Natural resources
- Long term strategy, vision
- Industrial structure, Organization of R&D
- Role of other agents
- Competitive factors
- Demand side factors

US & German Patent Specialisation Ranks 1993/94

United States	Germany
1. Information Technology	1. Civil Engineering
2 Medical engineering	2. Nuclear engineering
3 Semiconductors	3. Agricultural machines
4 Organic chemistry	4. Transport
5 Optics	5. Engines
26 Consumer goods	26. Semiconductors
27 Agricultural machines	27. New materials
28 Nuclear engineering	28. Audiovisual technology
29 Civil engineering	29. Optics
30 Machine Tools	30. Information technology

Source: Specialization index of European Patent Office (EPO) patents of German and United States Origin in relation to the average distribution at the EPO for the period 1993 to 1994. The rankings are derived from the complete tables in Harhoff and Soskice (forthcoming) based on the methodology introduced in ISI/FhI 1997. The ranking for biotechnology is 6 in the United States and 22 in Germany.

Source: Casper

National institutional frameworks in Germany and the UK

	Germany	UK
Labour law	Regulative (coordinated system of wage bargaining; constraints on employee dismissals)	Liberal (decentralised wage bargaining; fewer barriers to employee turnover)
Company law	Stakeholder system (two tier board system plus codetermination rights for employees)	Shareholder system (minimal legal constraints on company organisation)
Skill formation and technology transfer	Organised apprenticeship system with substantial involvement from industry. Close links between industry and technical universities in designing curriculum and research	No formal apprenticeship system for vocational skills. Links between universities and firms almost exclusively limited to R&D activities and R&D personnel
Financial system	Primarily bank-based with close links to stakeholder system of corporate governance; no hostile market for corporate control	Primarily capital market system, closely linked to market for corporate control and financial ownership and control of firms

Innovation Systems

» National Innovation Systems

- Kn. Production and application increasingly a joint activity
- High levels of interdependence
- Patterns of specialised asset accumulation eg specialist venture capital
- Policies and culture supportive of flexibility and entrepreneurship

» Regional Innovation Systems

- Long history of interest in regional concentrations of industry and innovation
- Clusters – Porter: Related and supporting industries, demand conditions, factor conditions, rivalry. Often key role by demanding customers
- Eg Finnish Forest Cluster
- Rapid transfer of learning, sharing of high cost assets, reduction of uncertainty

Innovation Systems

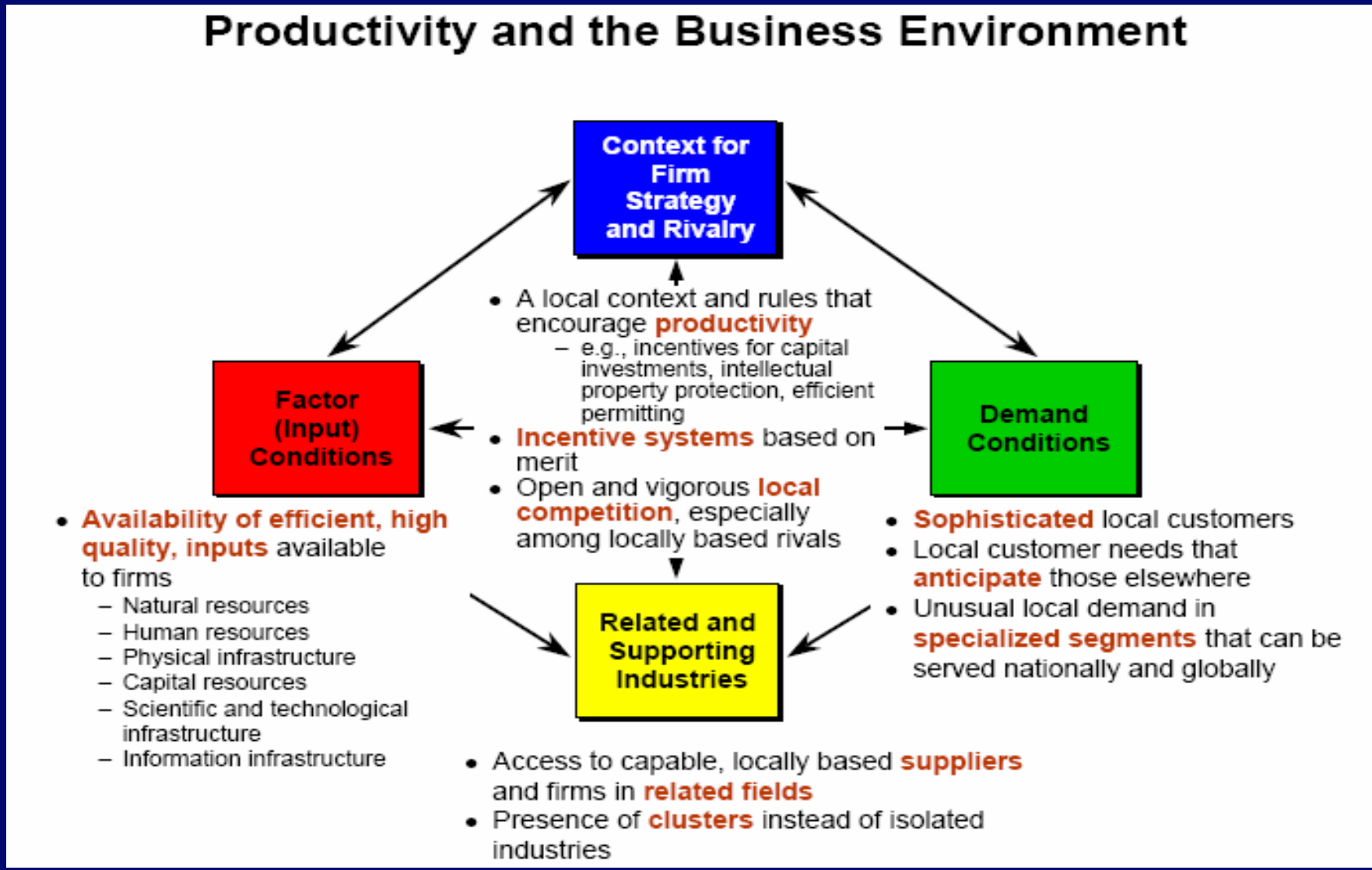
» Sectoral Innovation Systems

- More recent focus of analysis
- Shared trajectories- same sectors in different countries have more in common than different sectors in the same country
- Collective problem solving

» Technology Systems and Chains

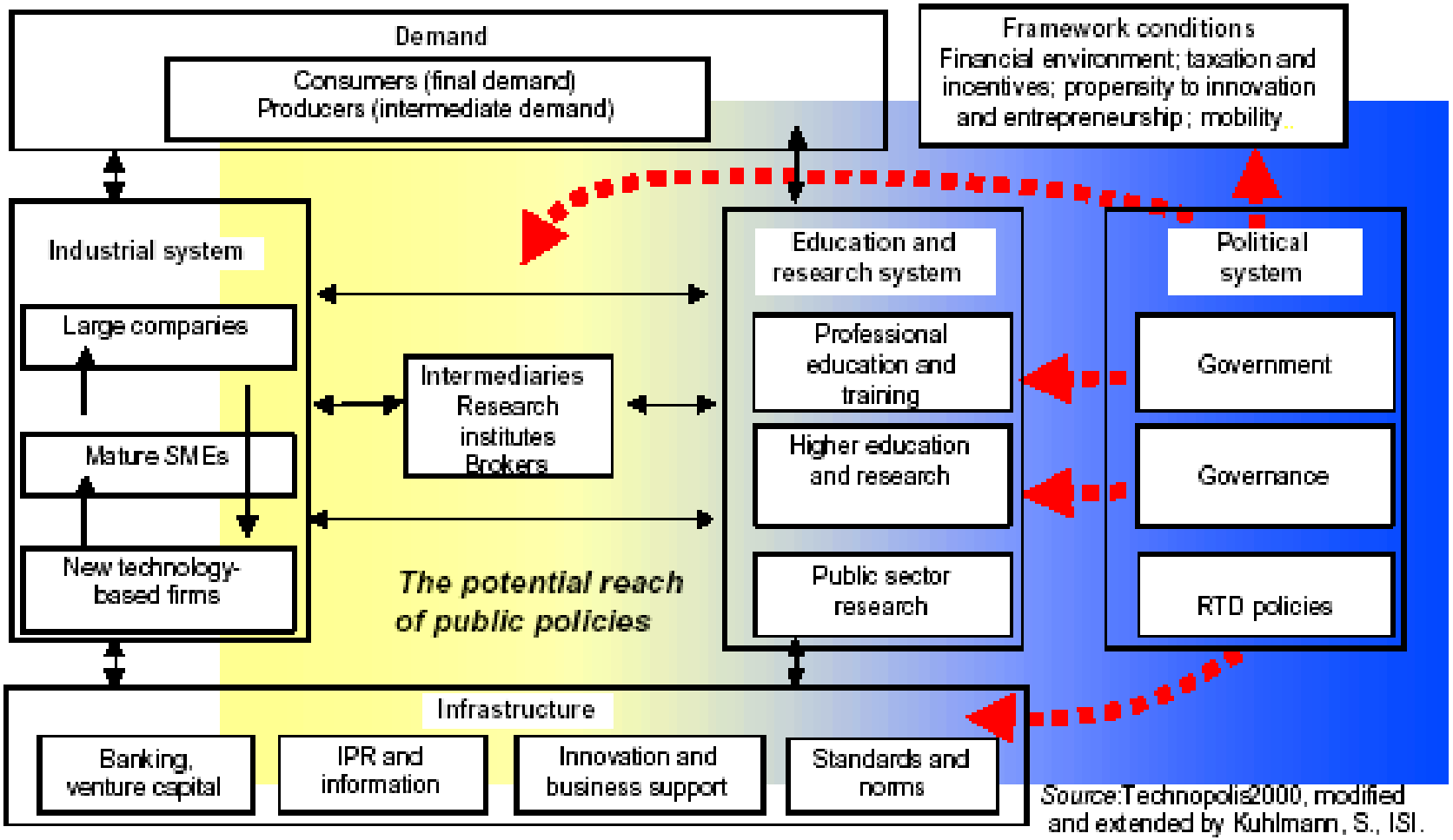
- Role on interaction for production and innovation
- Interdependence – complementary capabilities

Productivity and the Business Environment



Source: Porter

Innovation Systems Model



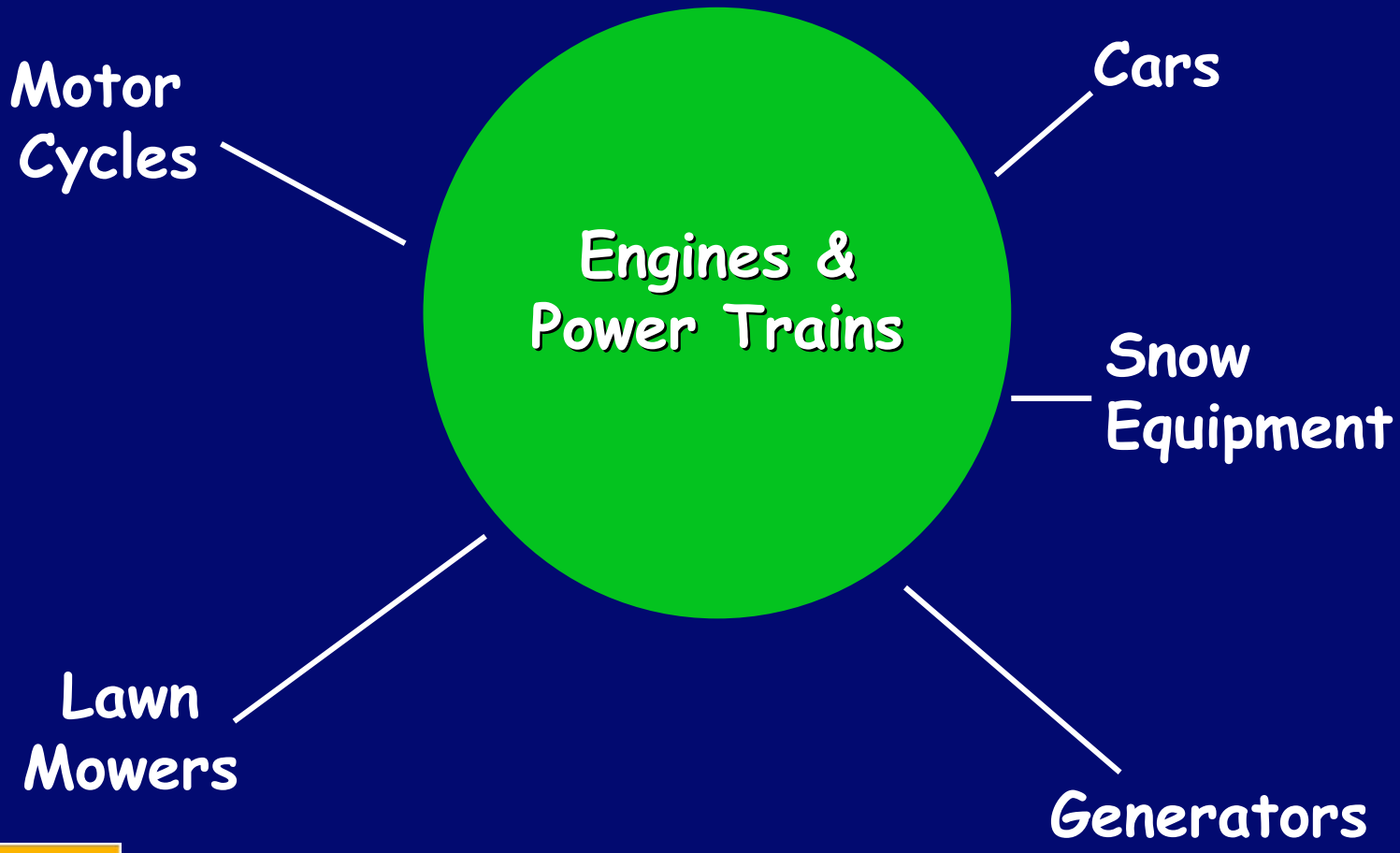
Appropriating the returns to Innovation

- Secrecy
- Tacit knowledge
- Lead times and service
- Learning curve
- Complementary assets
- Product complexity
- Standards
- Pioneering Radical products
- Strong Patent protection

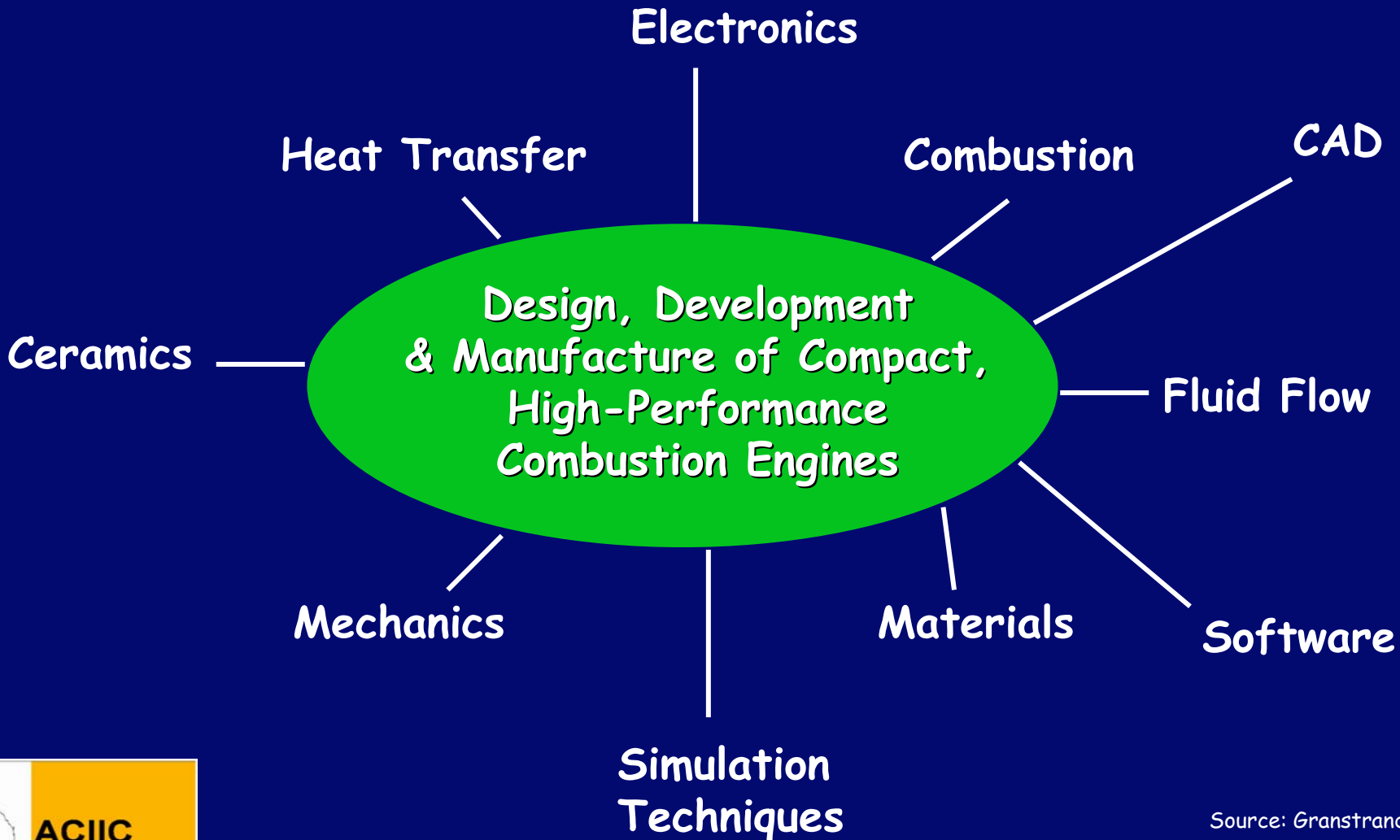
Paths:
Technological Trajectories.

Asset re-use.

Honda's Core Competencies

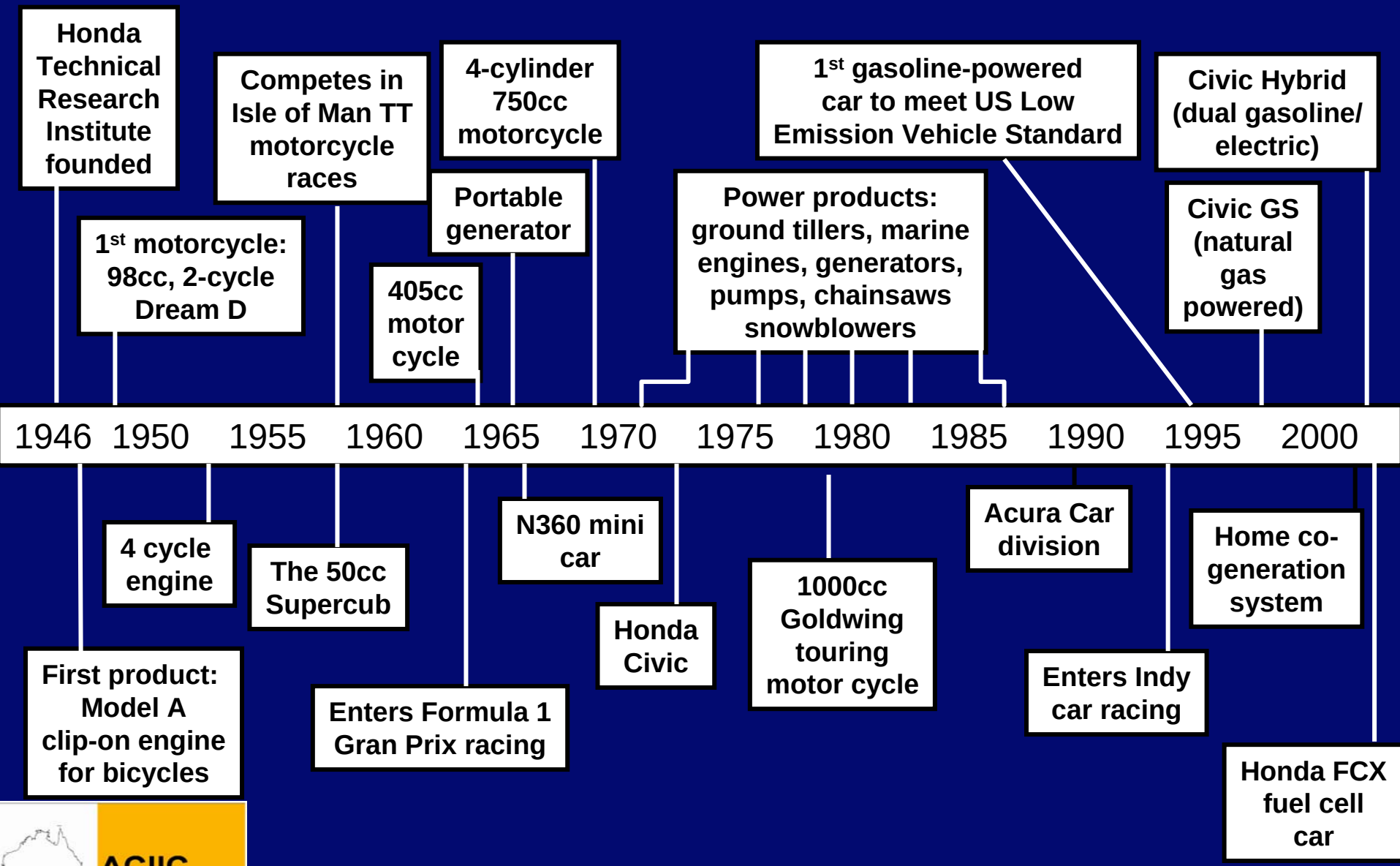


Technological Basis of Honda's Core Competencies



Source: Granstrand er al

The Evolution of Honda Motor Co.



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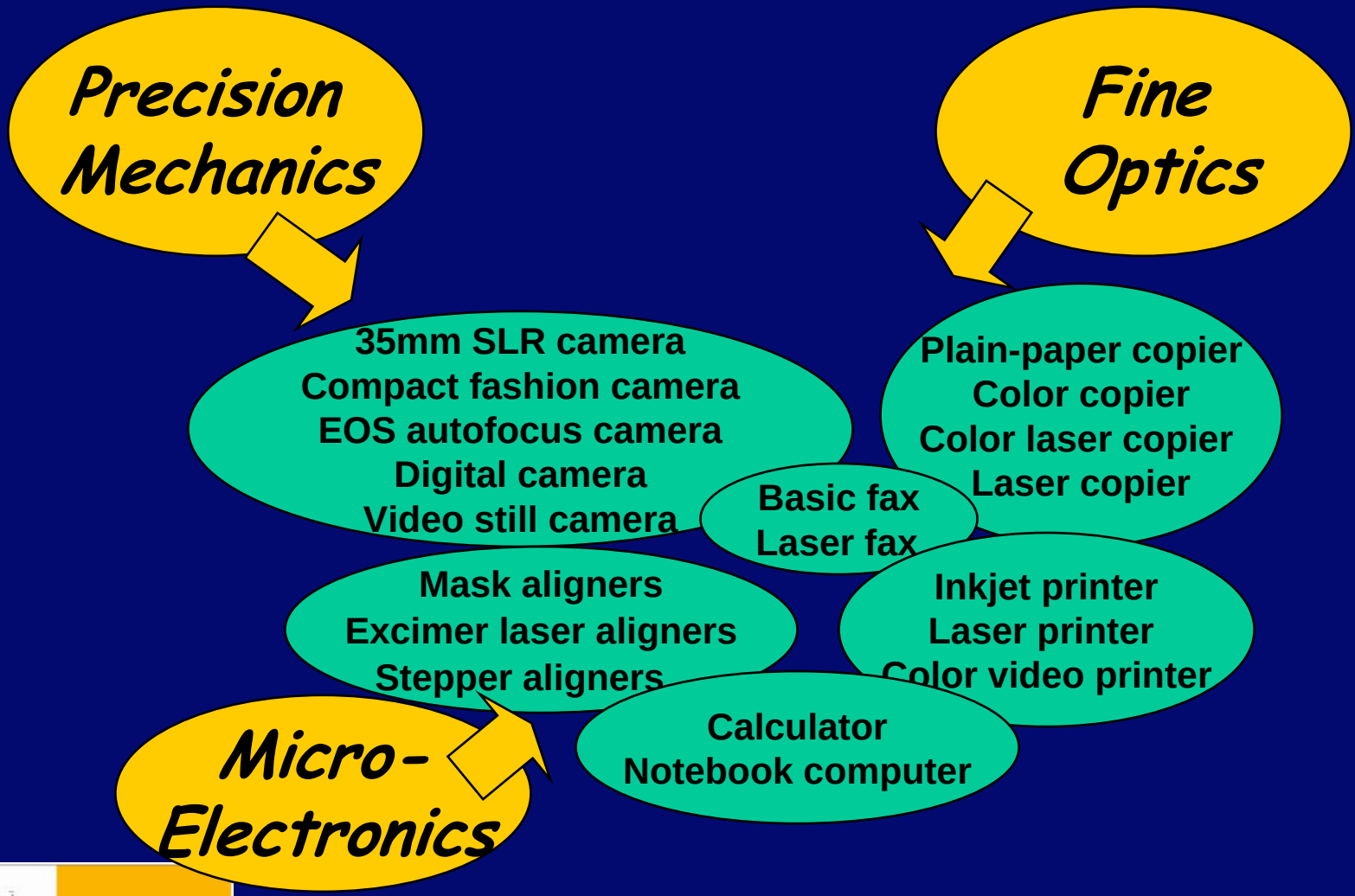
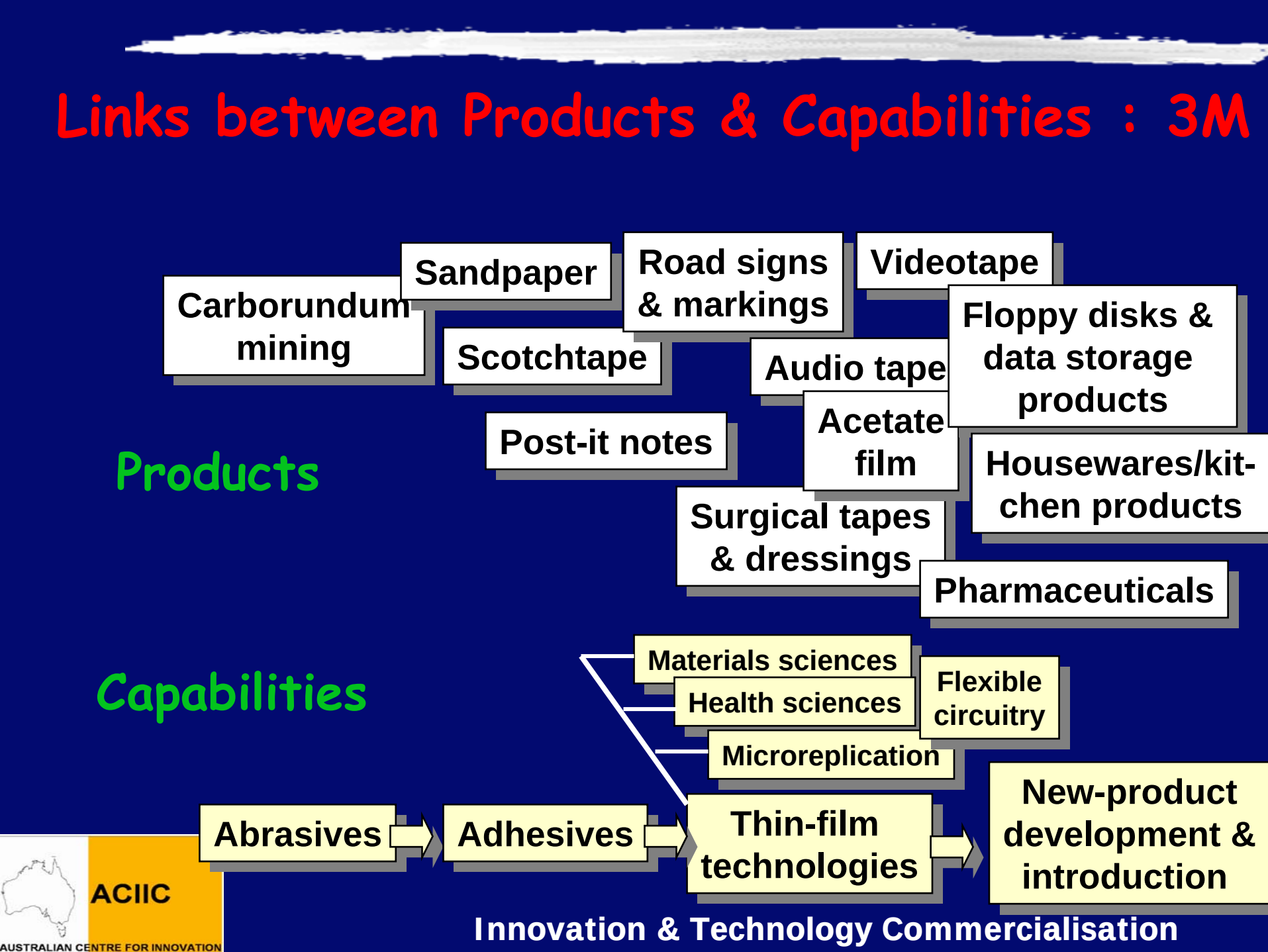
Canon: Products and Core Capabilities



Links between Products & Capabilities : 3M



Eastman Kodak's Dilemma

Resources & Capabilities

Businesses

1980's

Chemical Imaging
- •Organic Chemistry
- •Polymer technology
- •Optomechtronics
- •Thin-film coatings

Brands

Global Distribution

Film

Cameras

Fine Chemicals

Pharmaceuticals

Diagnostics

1990's

DIVESTS: Eastman Chemical, Sterling Winthrop, Diagnostics

Need to build digital imaging capability

Digital Imaging Products (e.g. Photo CD System; Advantix cameras & film

Core competence

A company must be viewed not only as a portfolio of products or services, but a portfolio of competencies as well

Core capabilities - 4 dimensions

- Employee knowledge and skills embedded in technical systems.
- The processes of knowledge creation and control are guided by managerial systems
- the values and norms associated with the knowledge creation and control

The core competence perspective

Five key competence management tasks:

- identifying existing core competencies
- a core competence acquisition agenda
- building core competencies
- deploying core competencies
- protecting and defending core competence leadership

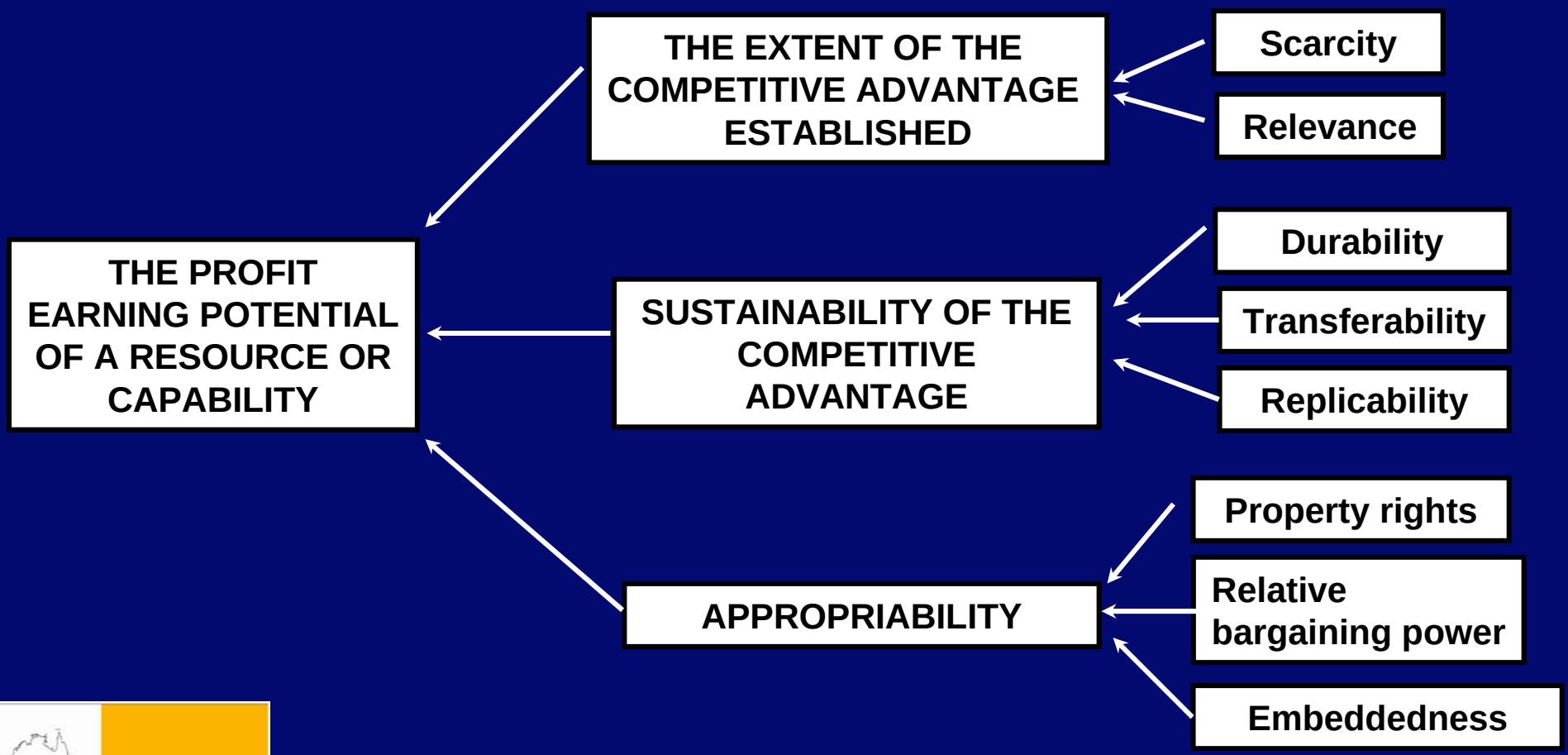
Core Competencies

- Core competencies may not continue to provide a source of competitive advantage
- Core Rigidities are former core competencies that lead to inertia and a lack of response to change
- Strategic short sightedness and inflexibility can cripple a firm's ability to grow and adapt to environmental change, opportunity or threats

Appraising Resources

RESOURCE		CHARACTERISTICS	INDICATORS
Tangible Resources	Financial	Borrowing capacity Internal funds generation	Debt/ Equity ratio Credit rating Net cash flow
	Physical	Plant and equipment: size, location, technology flexibility. Land and buildings. Raw materials.	Market value of fixed assets. Scale of plants Alternative uses for fixed assets
Intangible Resources	Technology	Patents, copyrights, know how R&D facilities. Technical and scientific employees	No. of patents owned Royalty income R&D expenditure R&D staff
	Reputation	Brands. Customer loyalty. Company reputation (with suppliers, customers, government)	Brand equity Customer retention Supplier loyalty
Human Resources		Training, experience, adaptability, commitment and loyalty of employees	Employee qualifications, pay rates, turnover.

Competitive Potential of Resources & Capabilities



Building New Core Competencies

- Forecasting
- Trial and error
- Learning

Product Sequencing to Build Capabilities at Hyundai

Capabilities

Products

1968	1970	1974	1985	1994-95
•Assembly •Production engineering •Local marketing	•Auto styling &design •Casting & forging •Chassis design •Tooling •Body production •Export mktg.	•FWD engineering •CAD/CAM •Assembly control systems •Advanced component handling	•Hydrodynamics •Thermodynamics •Fuel engineering •Emission control •Lubrication •Kinetics& vibration •Ceramics •Electronic control systems	•Large-scale design integration •Global logistics •Lifecycle engineering
SKD CKD Ford Cortina	Pony	Excel	'Alpha' engine	Accent Avante Sonanta

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Shapers of Innovation

- Size of firm
- Sector
- National and regional innovation context
- Industry/technology life cycle
- Degree of novelty

Type of technology firm

Typical core sectors

Supplier-Dominated	Scale-Intensive	Information-Intensive	Science-Based	Specialized Suppliers
Agriculture	Bulk materials	Finance	Electronics	Machinery
Services	Autos	Retailing	Chemicals	Instruments
Traditional Manufacturing	Civil Engineering	Publishing Travel	Drugs	Software

Type of technology firm

Main sources of technology

Supplier-Dominated	Scale-Intensive	Information-Intensive	Science-Based	Specialized Suppliers
Suppliers Learning from Production	Production Engineering, Learning from production, Design offices, Specialized suppliers	Software & Systems depts, Specialized suppliers	R&D Basic research	Design, Advanced users

Type of technology firm

Main tasks of technology strategy

Supplier-Dominated	Scale-Intensive	Information-Intensive	Science-Based	Specialized Suppliers
Use technology from elsewhere to strengthen other competitive Advantages	Incremental integration of changes in complex systems, Diffusion of best design & production practice	Design & operation of complex information processing systems, Development of related products	Exploit basic science, Development of related products, Obtain complementary assets, Redraw divisional boundaries	Monitor advanced user needs, Integrate new technology incrementally

Shapers of Innovation

- Size of firm
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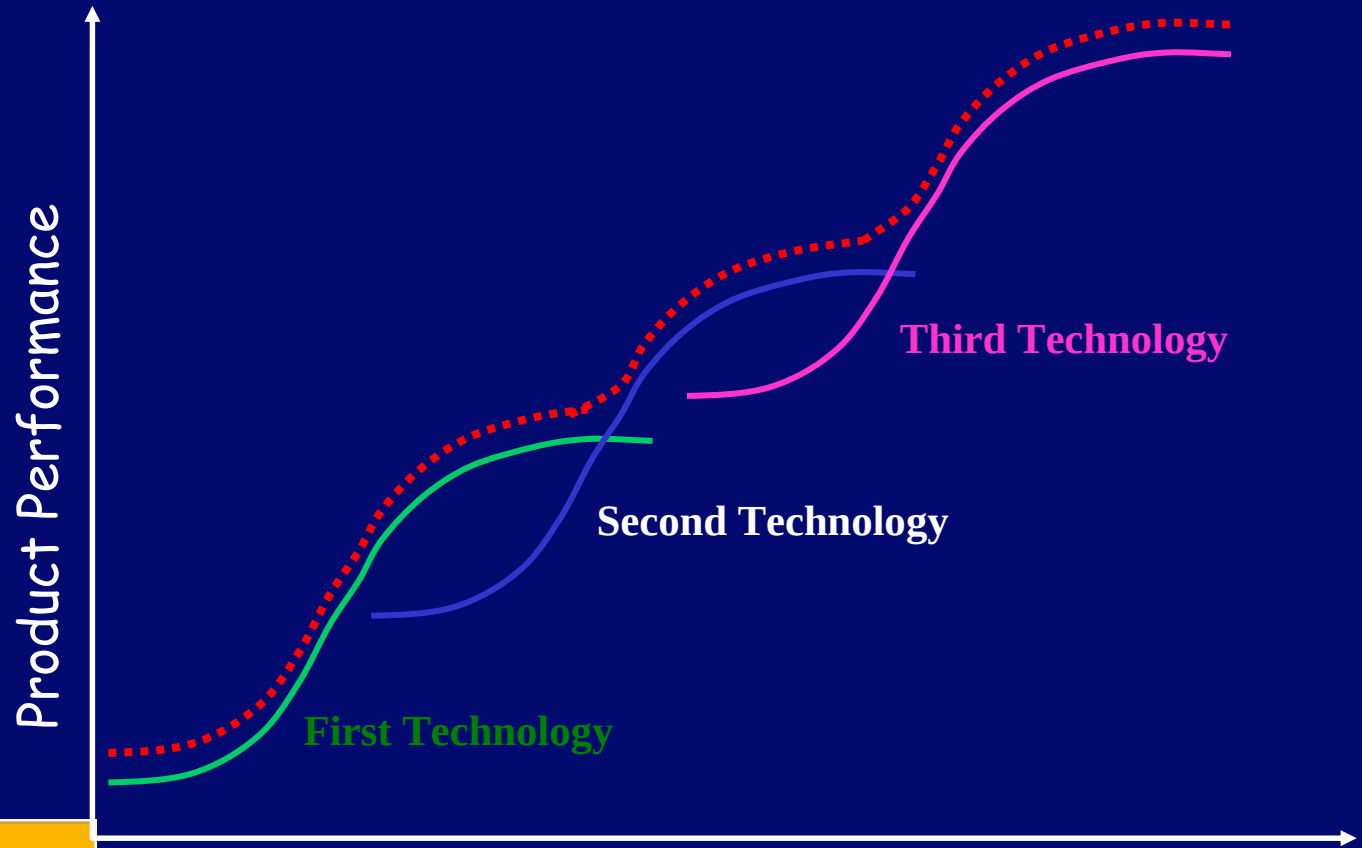
Conventional Technology S-Curve



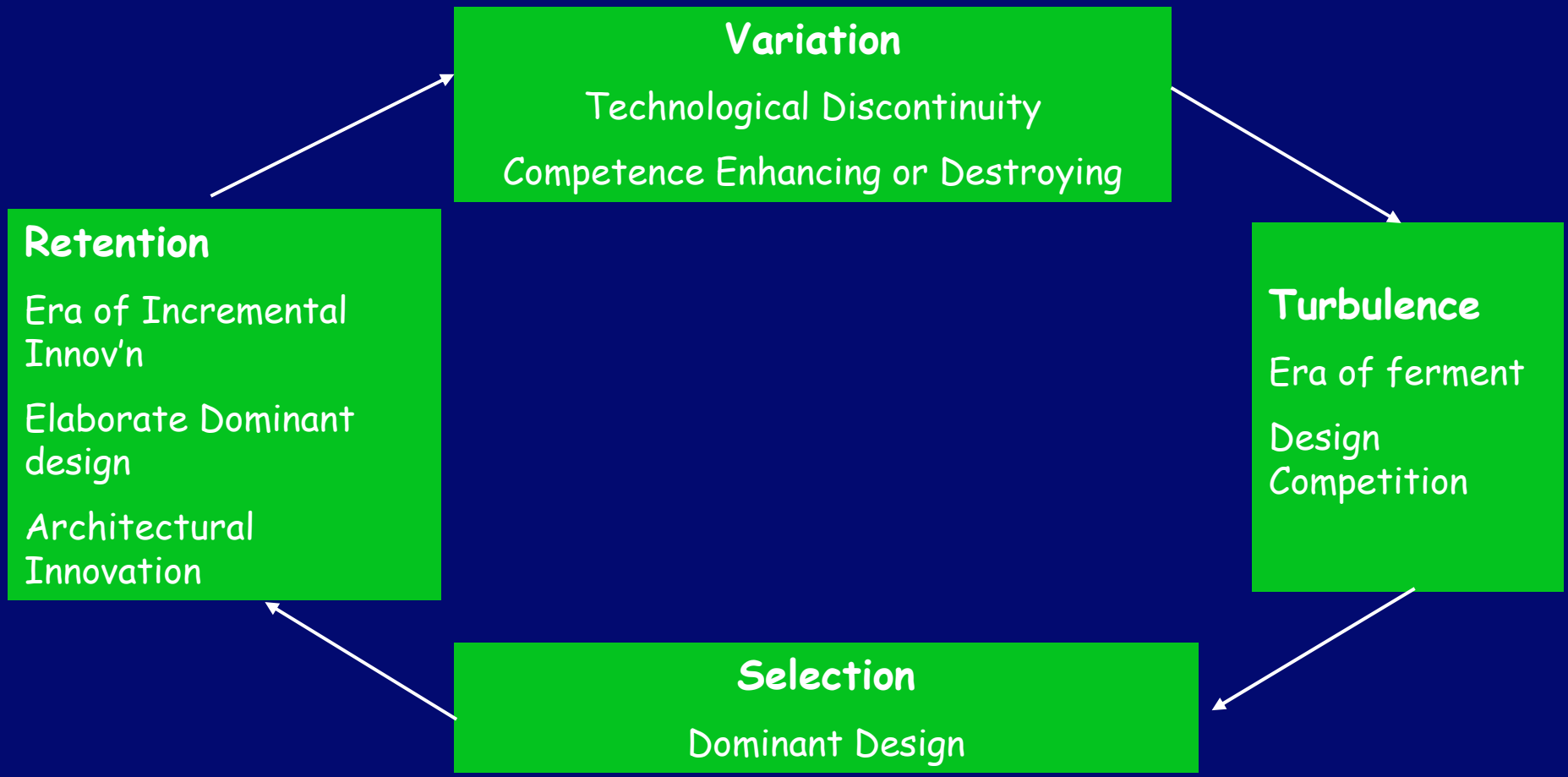
Types of Innovation - 1

Sustaining / Incremental Innovation: generally small innovations in products and processes aimed at existing customers.

Disruptive / Discontinuous Innovation: significant innovations generally aimed at unknown or non-existent customers.

Source: Haberman

A Typical Technology Cycle



Dominant Design

A Dominant Design Functions to:

- help integrate the industry as a system with a specific solution embodied in an accepted **product design**.
- concentrate efforts of participants in industry onto refining that solution and bringing down **cost of production**
- Firms' specialist roles are co-ordinated around leading designs

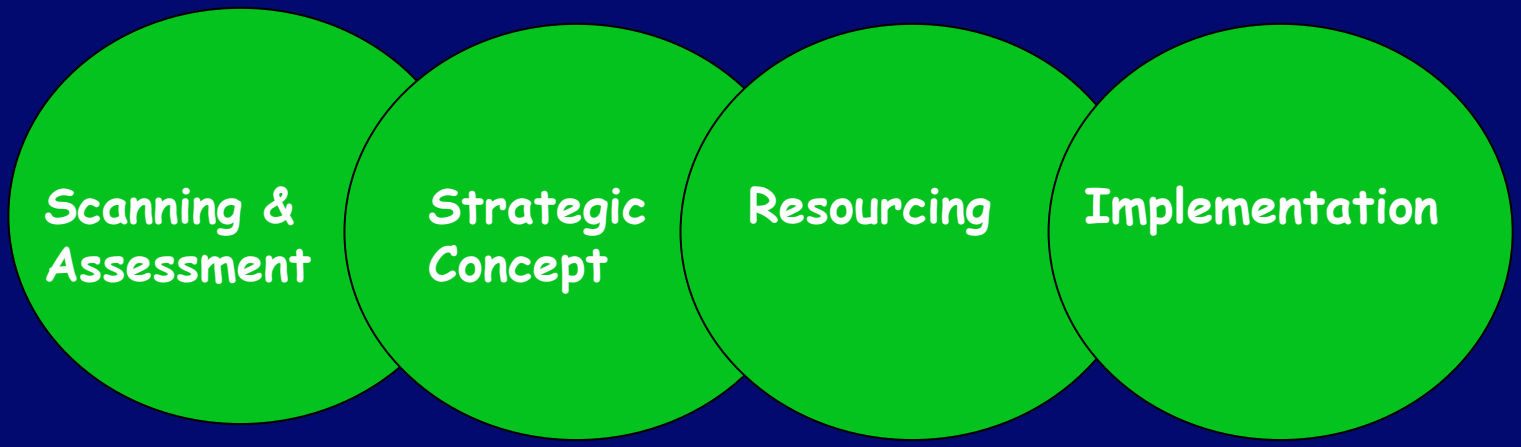
Focus of Innovation

Innovation profile shifts in maturing industries

- Effort shifts from product to process innovation
- Competition increases, pressure to reduce costs and improve production process.
- Many failures and mergers
- Increasing efforts to streamline production
- production process innovations increase

Managing Innovation Processes

Stages in the Innovation Process



Routines

Corporate Routines

From Tidd, Bessant and Pavitt

Managing Innovation Processes

- What are the key innovative capabilities?
- Where can new technology be acquired from?
- How can a firm learn about new technologies?
- Is there an ideal innovation strategy?

Innovative Capabilities

- *Forecasting & Assessing*
- *Searching & Selecting*
- *Acquiring & Protecting*
- *Implementing*
- *Aligning*

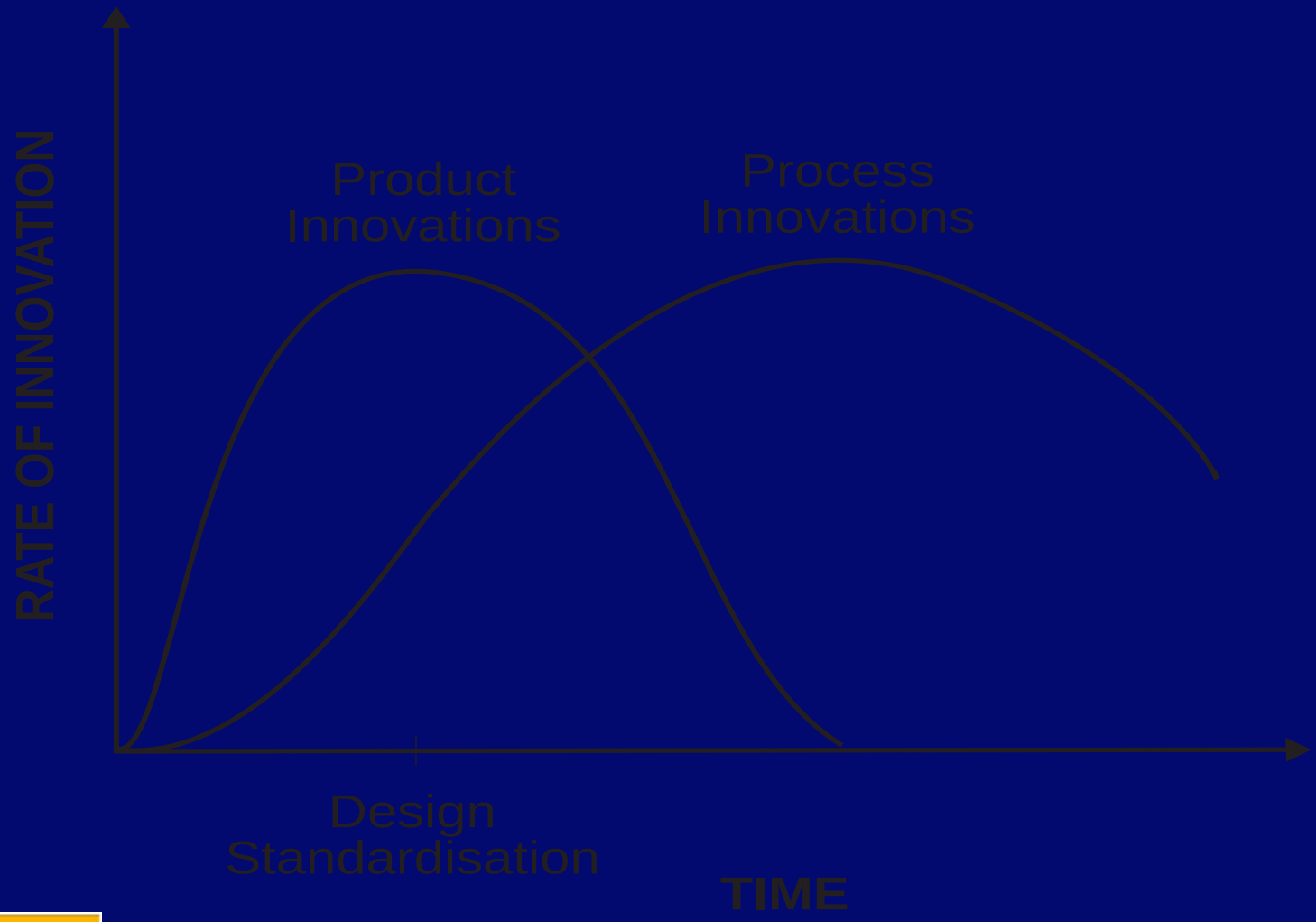
  -- technology plans to technology audits

  -- technology & business strategy
- *Integrating*

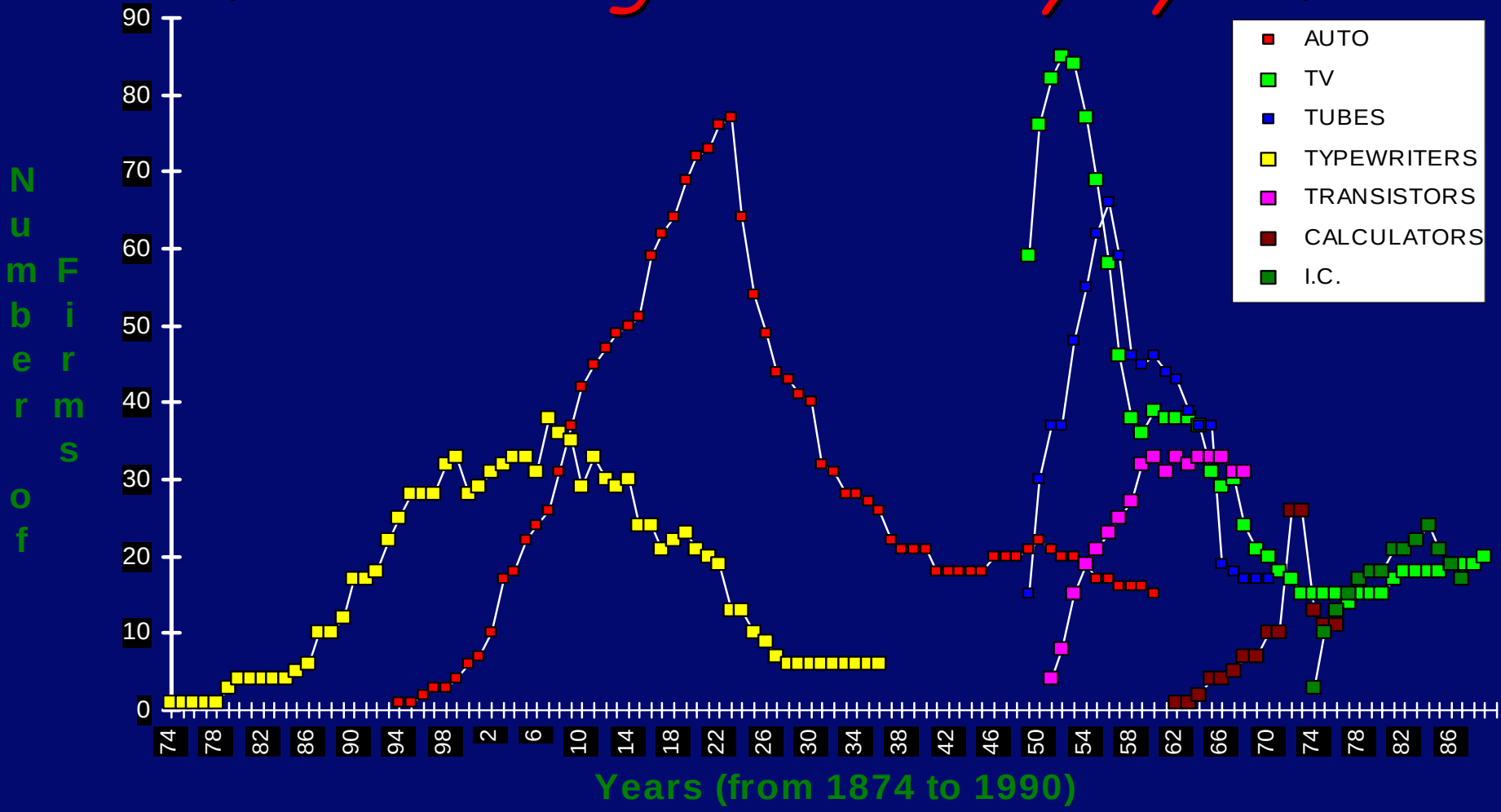
  -- different functions & divisions

  -- external & internal inputs
- *Combining*
- imaginative & entrepreneurial combination of resources to create competitive advantages
- *Learning*

Forecasting -1

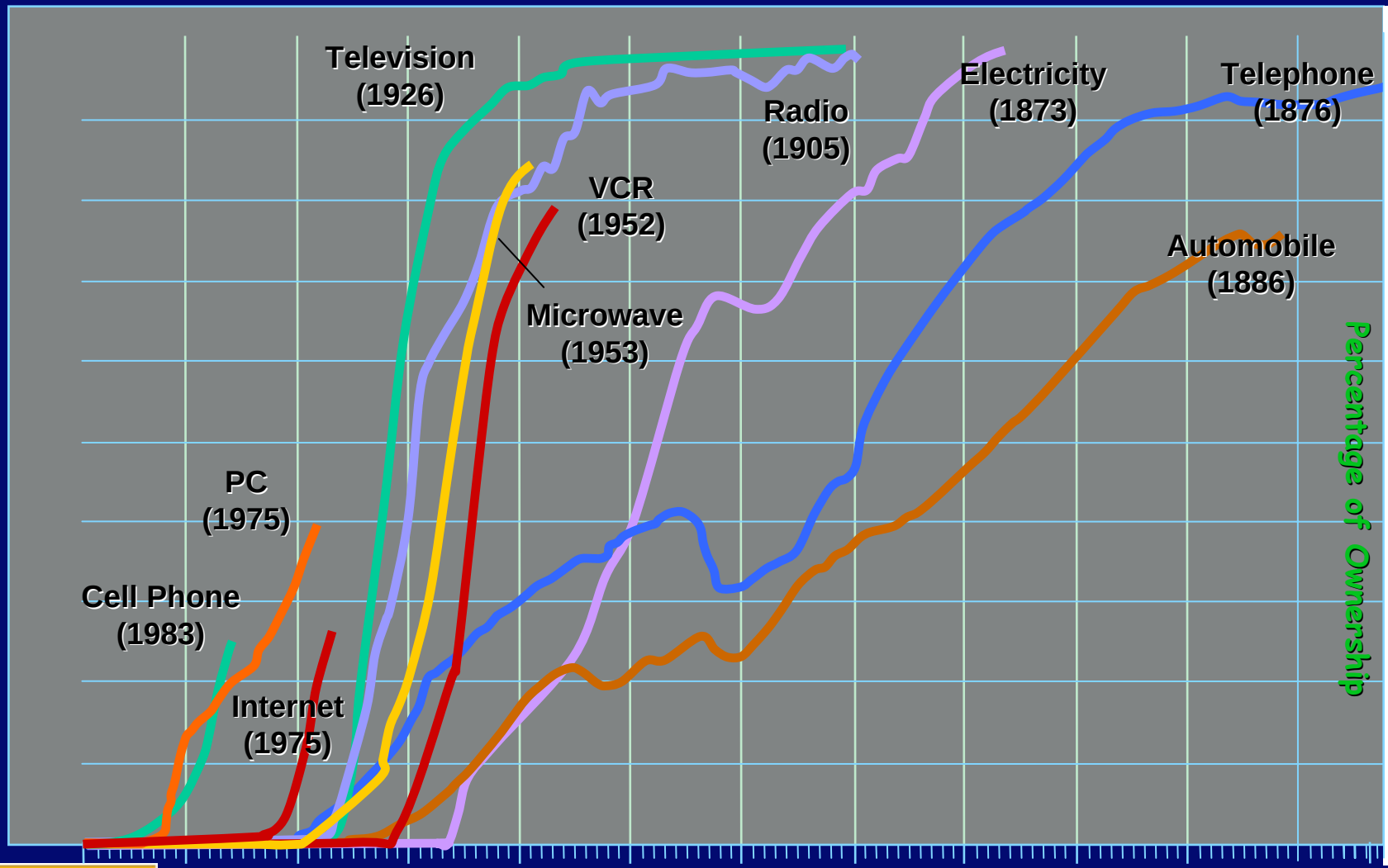


Dominant designs:Industry dynamics



Derived from Debackere

Technology Rate of Adoption (1/2)



Source: Raymond Kaptain, Microsoft

Technology Rate of Adoption

- Most new technologies typically require many years to become a new standard.
- As shown in the previous graph, the number of years it took for the following technologies to reach 25% of U.S. households are as follows:

Automobile = 56 years

Electricity = 45 years

Telephone = 36 years

Microwave = 31 years

Television = 26 years

Internet = 23 years

Cell phone = 14 years

Search through, for example:

- basic research
- patent search
- bibliometrics
- attending conferences & exhibitions
- literature search
- industrial espionage

Searching is becoming much more sophisticated.

Acquiring, Commercialising & Protecting

Technology Acquisition

- R&D
- Licensing
- Purchase

Governance of Commercialisation

- Arms Length/Market
- Integration
- Collaboration

Methods of Acquiring Technology

How do firms acquire knowledge ie learn?

Methods of Learning About Technology

- Learning through **links with science base**
- Learning through **collaboration and joint ventures**
- Learning through **subcontracting**
- Learning by **doing and using**
- Learning through **training and recruitment**
- Learning through **reverse engineering**
- Learning through **DFI**
- Learning through **competitor evaluation**
- Learning through **licensing**
- Learning through **distribution and marketing**
- Learning by **failing**
- Learning through **M&A**
- Learning through **consultancy exercises**

An Innovative Capabilities Audit Framework

- **1. Resource Availability and Allocation**

- Level of R&D funding and evolution:
  - In absolute terms; % sales, % of overall corporate R&D.
  - As compared to main competitors and leading competitor..
- Breadth and depth of skills at business unit level in R&D, engineering, and market research.
- Distinctive competences in areas of technology relevant to business unit.
- Allocation of R&D to:
  - Existing product/market combinations.
  - New product development for existing product categories.
  - Development of new product categories.

- **2. Understanding Competitors' Innovative Strategies and Industry Evolution**

- Intelligence systems and data available.
- Capacity to identify, analyze, and predict competitors' innovative strategies.
- Capacity to identify, analyze, and predict industry evolution.
- Capacity to anticipate facilitating/impeding external forces relevant to business unit's innovative strategies.

An Innovative Capabilities Audit Framework- 2

3. Understanding the Business Unit's Technological Environment

- Capacity for technological forecasting relevant to business unit's technologies.
- Capacity to assess technologies relevant to business unit.
- Capacity to identify technological opportunities for business unit.

4. Business Unit Structural and Cultural Context

- Mechanisms for managing R&D efforts.
- Mechanisms for transferring technology from research to development.
- Mechanisms for integrating different functional groups (R&D, engineering, marketing, manufacturing) in the new product development process.
- Mechanisms for funding unplanned new product initiatives.
- Mechanisms for eliciting new ideas from employees.
- Evaluation and reward systems for entrepreneurial behavior.
- Dominant values and definition of success.

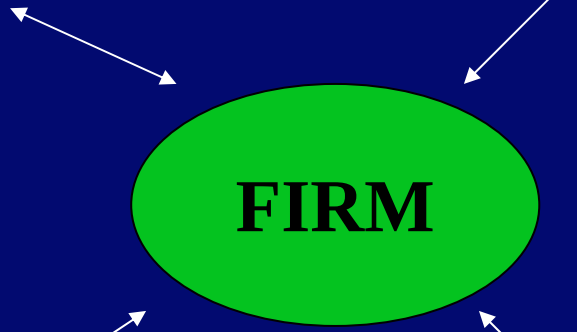
5. Strategic Management Capacity to Deal with Entrepreneurial Behavior

- Business unit level management capacity to define a substantive development strategy.
- Business management capacity to assess strategic importance of entrepreneurial initiatives.
- Business management capacity to assess relatedness of entrepreneurial initiatives to core capabilities.
- Capacity of business unit level management to coach product champions.
- Quality and availability of product champions in the business unit.

Growing Importance of Technology Strategy

Time
Faster,
Shorter life cycle

Technological Paradigm Shift



Technological
(Fusion, Complexity, Cost, Discontinuity)

Environmental
(Deregulation, Global Competition, Product liability)

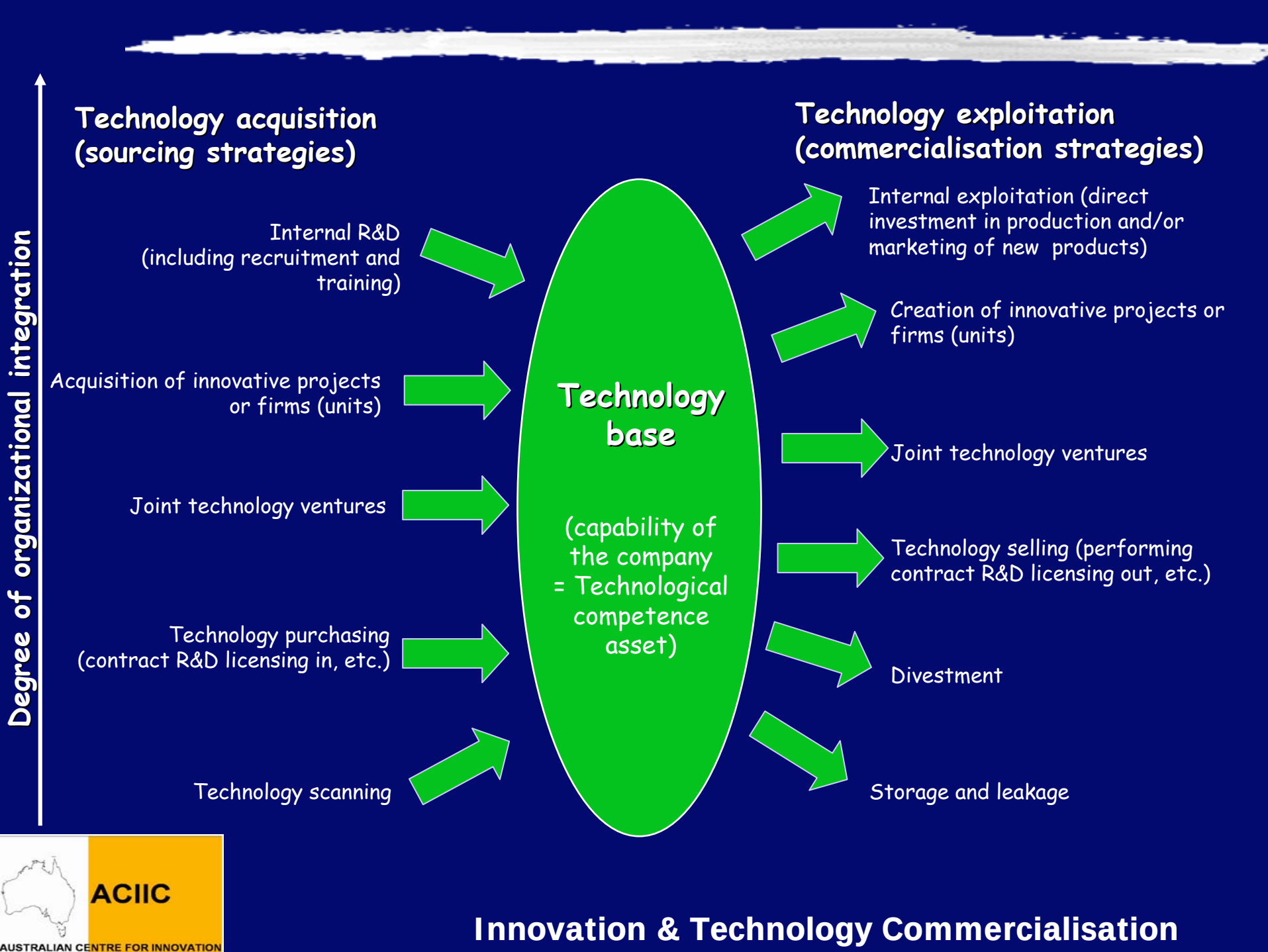
Why Is Technology Strategy Important?

- Because the development & use of technology is a key source of **competitive advantage**
- The **complex**, **uncertain** and **expensive** process of R&D, NPD & manufacturing need to be guided by a strategy which builds synergies & grows expertise cumulatively
- The **globalization** of technology & markets
- Existing strategies which do not integrate technology strategically tend to fail
- Because innovation is increasingly collaborative potential partners need to understand your strategies

A typology of technology strategies

- Lead: technological & market leadership: strong R&D & significant investments in search & selection
- Follow: follow technology leaders
- Defend: defending existing technologies & incremental improvements

Source: Freeman and Soete, 1997



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Strategic Positions

Strategic objective

	Internal	External
Transform	New Businesses New & Disruptive technology Development via corporate funding	New Ventures New & Disruptive technology •New spin-outs •Joint ventures
Exploit	Sustainable Core Businesses Core Technology Strong technology & efficient product development	Growing Valuations Holding portfolio •Passive holding of spin outs •Licensing in Non competitive fields

Channel

The Innovator's Dilemma

- "when new technologies cause great firms to fail"
Christensen, 1997

Well-managed firms; those that:

- listen to their customers
- invest aggressively in new technologies
- provide customers with more & better products of the sort they need
- carefully study market trends
- systematically allocate investment capital to innovations that produce the best returns

Consistently lose their leadership position in a wide range of industries

Leaders in one generation of disk drive (14", 8", 5.5", etc) were displaced in the next

Balancing

Radical innovation

- Change
- Diversity
- Sustainability
- Dependence on internal assets
- Leadership

Incremental Innovation

- Stability
- Focus
- Profit maximising
- Dependence on external assets
- Responsiveness

Key Strategic Management of Technology Tasks

- Technology Plans
- Technology Assessment/ Forecasting
- R&D Project Selection - Balancing the Portfolio
- Defining & Building Competencies
- Building & Using Internal & External Links
- Coordinating & Integrating Technology with Corporate Strategy
- Communicating Strategy
- Building a Learning Organization

Innovation Capabilities

- Reside at multiple levels in an organisation
  - Corporate, line-of-business, functional, and individual
- Multiple dimensions
  - Physical systems (software, hardware, technical)
  - Managerial systems (incentive systems, business processes, policies, and procedures)
  - Skills and knowledge (employees, firm-specific, industry-specific, scientific)
  - Values (beliefs, behavior, corporate "religion")
    - **Listed from least to most difficult to change**

R&D

- What are the outputs of R&D?
- How do we best measure/evaluate the effectiveness of R&D