Innovative industrial renewal in industrial ecosystems

Lessons from the Emilia Romagna case

Antonio Andreoni

Senior Lecturer in Economics, SOAS University of London
(Incoming Associate Professor of Industrial Economics, UCL)
Outline

• Analytical frameworks matter to visualise opportunities and develop innovative industrial renewal pathways

• Opportunities for diversification and innovative industrial renewal are often nested in the productive structure of industrial ecosystems

• Innovative industrial renewal can follow different sectoral and cross-sectoral pathways (increasingly cross-sectoral given digitalisation)

• Industrial restructuring and industrial policy alignment is critical, especially when innovative industrial renewal requires technology fusion

• Challenges of peripheral regions in the digitalisation era
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The Dynamics of Industrial and Economic Renewal in Mature Economies: Implications for Theory and Policy

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Focus

• De-industrialisation and dualism across and within regions in mature industrial economies

• Innovative industrial renewal and restructuring of regions and countries: how do we think about it? what can we learn from transforming regions?

• Re-thinking industrial policies, beyond innovation policies: addressing the very place-specific organisational and technological dynamics of the new production systems

Introduction to the Special Issue: Towards a production-centred agenda

Antonio Andreoni, Ha-Joon Chang, Sue Konzelmann and Alan Shipman*

1. Introduction

Over the last two decades, the global industrial landscape has been dramatically re-shaped by profound structural and technological transformations. Global and regional production networks have redesigned the sectoral composition of economies as well as the geography of production and international trade. Sectoral boundaries have become increasingly blurred, as a result of processes of outsourcing and industrial re-organisation along multi-tiered supply chains. The migration of production to lower-cost countries, via relocation or outsourcing, has created challenges and opportunities for continuing operations in higher-cost countries, in services as well as manufacturing (Milberg and Winkler, 2015; Gereffi and Lee, 2016; Lee et al., 2017; Montori, 2017). Technological change has also played a critical role in triggering forms of ‘genetic mutation’ of traditional sectors and their boundaries. For example, in some countries, a traditional sector like agriculture has been transformed in a high-tech sector where vertical farming integrates complex automated feed systems relying on sensors and advanced biotechnologies, while self-driving tractors operate through satellite control systems. Similarly, production processes in traditional heavy industries have been augmented by digital technologies and advanced materials, allowing for virtual product and process development, scaling-up and testing (Andreoni and Chang, 2016).

Emerging technologies and their integration into complex technological systems have led to fundamental shifts in patterns of manufacturing production and consumption; and the widespread application of automation, robotics and digital technologies in advanced manufacturing systems—coupled with new developments in nanotechnologies and biotechnologies—have accelerated the pace of technological change, while increasing systemic inter-dependencies between organisations, industries and regions.

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Address for correspondence: Sue Konzelmann, Department of Management, Birkbeck, University of London, Malet Street, Bloomsbury, London WC1E 7HX, UK; email: s.konzelmann@bbk.ac.uk

Department of Economics, SOAS, University of London (AA); Faculty of Economics and Centre of Development Studies, University of Cambridge (HJC); Department of Management, Birkbeck, University of London (SK); and Faculty of Arts & Social Sciences, Open University (AS).

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Special issue contributions

• Theory and practice of smart specialization in Europe and how to integrate value creation strategies with value capture strategies (e.g. bottleneck assets) across Europe / US

• District/agglomeration effects and the capability/impact on Medium size firms for industrial renewal in Italian districts

• ‘home-sourcing’ and the emergence of closer value chains in the Spanish manufacturing industries

• Demand-pull dynamics of renewal though service outsourcing by foreign manufacturing enterprises in UK local labour markets

• industrial ecosystems and diversification dynamics, the capability-habitat interplay and the variety of possible learning, unlearning and forgetting processes

• management of technological change for inclusive growth.
Specialisation in manufacturing (NUTS 2 regions, MVA)

- emergence of a manufacturing “core” set of regions concentrated around German’s southern regions (Baden-Wurttemberg and Bayern) and Czech republic

- de-industrialisation in certain regions

- emergence of fragmented “manufacturing islands”
Outline

• **Analytical frameworks matter to visualise opportunities and develop innovative industrial renewal pathways**

• Opportunities for diversification and innovative industrial renewal are often nested in the productive structure of industrial ecosystems

• Innovative industrial renewal can follow different sectoral and cross-sectoral pathways (increasingly cross-sectoral given digitalisation)

• Industrial restructuring and industrial policy alignment is critical, especially when innovative industrial renewal requires technology fusion

• Challenges of peripheral regions in the digitalisation era
Structural transformations in global manufacturing and technological landscapes

- Over the past two decades, profound structural transformations in the global manufacturing and technology landscapes have reshaped the worlds of production and increasingly challenged established analytical frameworks and policies.

- The geography of production (ad trade) has been redesigned along “glo-cal” networks and production cycles involving heterogeneous organisations operating across regional and national boundaries.

- Firms have developed production, technological and market linkages beyond their regional and national systems (thus making difficult to identify their geographical boundaries), these linkages (especially the technological ones) have involved a limited number of countries, and a few regional agglomerations within them.
Structural transformations in global manufacturing and technological landscapes

- **Sectoral boundaries are also blurring** as a result of global processes of vertical disintegration and industrial reorganization along multi-tiered and modularised supply chains (Milberg and Winkler, 2013; Baldwin, 2016).

- **Technological change** and the rapid scaling up and diffusion of emerging technologies, as well as technology system integration within and across sectors, have resulted in the *“genetic mutation”* of traditionally defined industrial sectors.

- As a response to these increasingly complex production and technological interdependencies, as well as the need to capture value opportunities in global markets, **firms have experimented new industrial organization models**, beyond traditional hierarchical or market forms.
Systems of innovation literature

• Since the 1980s contributions in innovation system research and evolutionary economic geography, as well as others developed at the interface of structural, evolutionary and institutional economics,

• This enormous corpus of research remain largely disconnected, also concerns have been raised with regard to the capacity of these contributions of fully addressing the types of structural transformations and systemic interdependencies characterizing modern worlds of production.

• These transformations notably include dramatic changes in platform technologies (digitalization and robotisation), changes in the demand side of innovation (Weber and Truffer, 2017; OECD, 2017), and new industrial organization models characterised by co-opetition, co-adaptive and co-value creation dynamics.
Industrial and innovation system thinking

- The original idea of **National IS** (Freeman, 1987; Lundvall, 1992; Nelson, 1993) recognised the role of learning, linkages, interactions among different players (mainly supply side actors) and different institutional settlements, as main drivers of national innovation and competitiveness in developed economies and catching up ones (see the *triple helix* approach in this respect; Carlsson and Stankiewicz, 1991).

- **Regional IS** (Cooke et al., 2004) as well as localized learning models (Maskell and Malmberg, 1999) assigned special relevance to the regional scale and, thus, the role of proximity and localised capabilities.

- More recently, the **Sectoral System of Innovation and Production** (SSIP) approach (Malerba, 2004; Lee and Malerba, 2017) has stressed the importance of sectoral production systems as well as the role of demand side actors in innovation. Finally, the innovation system framework has been further broadened along the ideas of **Socio-Technical Systems** (Geels, 2004) and specified in terms of system functions within the *Technological Innovation Systems* research agenda (Hekkert et al, 2007).
Industrial and innovation system thinking: a critical appraisal

1. the changing geography of production makes more difficult to identify the “real” boundaries of a national or regional (even a district) system.

2. sectoral boundaries are constantly redefined by global production chain systems integrating different companies in complex multi-layered structures, while the same companies are undergoing forms of “genetic mutation”.

3. Third, understanding technological change in innovation systems today requires a stronger ‘engineering focus’ on technology platforms, different types of technologies constituting them, as well as the ways in which challenges in the scaling up of emerging technologies and their commercialisation affect value creation and capture dynamics (Tassey, 2007).

4. Fourth, while IS research tends to focus on relations and networks among heterogeneous actors, the structure of these networks remain often underexplored, and in some cases there is a tendency to rely on horizontal/flat network representations.

5. the political economy of these systems has remained largely unexplored
Architecture and Dynamics of Industrial Ecosystems

• a **new** stream of research has emerged around various concepts of ecosystems – i.e. **entrepreneurial, business, innovation and industrial ecosystem** > These approaches share the “biological analogy” of co-evolving systems involving a broad range of interdependent supply and demand side actors, co-existing and complementing each other in co-value creation processes.

• Industrial ecosystems as **hierarchic nearly-decomposable systems** involving **heterogeneous agents** operating within **multi-tiered sectoral value chains** and contributing to the **capability domains** of the ecosystem with closely complementary but dissimilar sets of resources and capabilities.
Industrial Ecosystem and its production space

• These resources and capabilities define the **production and technological bases** of these organisations and their **areas of specialisation** (Penrose, 1959).

• Thus, the industrial ecosystem is a **structured production space** centred mainly on its productive organisations, as well as other public actors, intermediaries and demand-side actors, purposefully involved in **co-value creation processes along various types of diversification** and innovative industrial renewal trajectories.

• The **geographical boundaries** of the industrial ecosystem are ultimately shaped by the evolving interdependencies linking organisations within the ecosystem and by the new linkages consolidating beyond that.
Outline

• Analytical frameworks matter to visualise opportunities and develop innovative industrial renewal pathways

• **Opportunities for diversification and innovative industrial renewal are often nested in the productive structure of industrial ecosystems**

• **Innovative industrial renewal can follow different sectoral and cross-sectoral pathways (increasingly cross-sectoral given digitalisation)**

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• Challenges of peripheral regions in the digitalisation era
# Contrasting regional pathways

<table>
<thead>
<tr>
<th></th>
<th>Emilia Romagna</th>
<th>Piedmont</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>4.4 million</td>
<td>4.4 million</td>
</tr>
<tr>
<td>GDP (2014)</td>
<td>144.14 B€</td>
<td>122.94 B€</td>
</tr>
<tr>
<td>GDP variation (2005-2014)</td>
<td>+13.2%</td>
<td>+2.4%</td>
</tr>
<tr>
<td>Unemployment (2015)</td>
<td>7.7%</td>
<td>9.2%</td>
</tr>
<tr>
<td>Unemployment (2006)</td>
<td>3.4%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Firms (2014)</td>
<td>370,259</td>
<td>336,338</td>
</tr>
<tr>
<td>Employees</td>
<td>1,518,243</td>
<td>1,331,000</td>
</tr>
<tr>
<td>NACE C Firms (2014)</td>
<td>38,742</td>
<td>33,454</td>
</tr>
<tr>
<td>Employees</td>
<td>453,089</td>
<td>415,161</td>
</tr>
</tbody>
</table>
### Table 2. Firm population and employment by sector and firm size in the ER region

<table>
<thead>
<tr>
<th>Industry</th>
<th>Firms 0-9 units</th>
<th>Firms 10-49 units</th>
<th>Firms 50-249 units</th>
<th>Firms &gt;250 units</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Firms</td>
<td>Employees</td>
<td>Firms</td>
<td>Employees</td>
<td>Firms</td>
</tr>
<tr>
<td>Food and beverage</td>
<td>4,094</td>
<td>14,214</td>
<td>794</td>
<td>14,426</td>
<td>118</td>
</tr>
<tr>
<td>Textile and apparel</td>
<td>4,542</td>
<td>13,342</td>
<td>782</td>
<td>13,530</td>
<td>78</td>
</tr>
<tr>
<td>Wood and paper</td>
<td>2,462</td>
<td>6,440</td>
<td>550</td>
<td>10,155</td>
<td>40</td>
</tr>
<tr>
<td>Petroleum</td>
<td>3</td>
<td>33</td>
<td>4</td>
<td>73</td>
<td>2</td>
</tr>
<tr>
<td>Chemicals</td>
<td>222</td>
<td>981</td>
<td>127</td>
<td>2,876</td>
<td>47</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>261</td>
<td>6</td>
</tr>
<tr>
<td>Rubber and plastics</td>
<td>1,709</td>
<td>5,534</td>
<td>490</td>
<td>14,144</td>
<td>141</td>
</tr>
<tr>
<td>Metal</td>
<td>5,425</td>
<td>17,454</td>
<td>1,664</td>
<td>31,963</td>
<td>173</td>
</tr>
<tr>
<td>Electronics</td>
<td>497</td>
<td>2,161</td>
<td>171</td>
<td>3,074</td>
<td>55</td>
</tr>
<tr>
<td>Electrical</td>
<td>705</td>
<td>2,205</td>
<td>279</td>
<td>5,507</td>
<td>53</td>
</tr>
<tr>
<td>Machinery</td>
<td>2,083</td>
<td>26,223</td>
<td>1,447</td>
<td>26,096</td>
<td>266</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>355</td>
<td>1,922</td>
<td>122</td>
<td>3,071</td>
<td>31</td>
</tr>
<tr>
<td>Other</td>
<td>6,076</td>
<td>14,354</td>
<td>699</td>
<td>12,314</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>360,977</td>
<td>90,128</td>
<td>11,148</td>
<td>141,698</td>
<td>1,079</td>
</tr>
</tbody>
</table>

Source: Own elaboration based on official data from ISMEA (2015).

### Specialisation in manufacturing industry

**NUTS-2 regions, 2015**

Manufacturing GVA share over GDP share (shares in total EU GVA and GDP)

- **below -0.5**
- **-0.5 to 0**
- **above +1.0**
- **0 to +0.5**

**Source:** WIW

### Industrial Ecosystem Architecture and Diversification Dynamics: Emilia Romagna case

**Capability domains**

- Capability domain 1: Bio, food and agro technologies
- Capability domain 2: Advanced materials
- Capability domain 3: Mechanical systems and automation
- Capability domain 4: ICT and embedded systems
- Capability domain 5: Biopharma and medical technologies

### Sectoral value chains

- Sectoral value chain 1: Medical device
- Sectoral value chain 2: Automotive
- Sectoral value chain 3: Agro-food industry
- Sectoral value chain 4: Packaging machinery industry
- Sectoral value chain 5: Chemical industry
- Sectoral value chain 6: Industrial construction
- Sectoral value chain 7: Energy & renewable

[Diagram showing the relationships between capability domains and sectoral value chains]

Lean
EGICON
ENKI
GAMMO
GVS
IMA
GD
Trevi
Dinamica Generale

[Diagram showing the relationships between capability domains and sectoral value chains]
Production Space: A structured space of opportunities and constraints

<table>
<thead>
<tr>
<th>Industrial Ecosystem Architecture</th>
<th>Sectoral value chains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Research &amp; Development</td>
</tr>
<tr>
<td></td>
<td>Product Design &amp; Supply</td>
</tr>
<tr>
<td></td>
<td>Production &amp; Integration</td>
</tr>
<tr>
<td></td>
<td>Distribution &amp; Marketing</td>
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<tr>
<td></td>
<td>Post-sale Services</td>
</tr>
<tr>
<td>Capability domains</td>
<td>Sectoral value chain 1</td>
</tr>
<tr>
<td></td>
<td>Sectoral value chain 2</td>
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<tr>
<td></td>
<td>Sectoral value chain 3</td>
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<tr>
<td></td>
<td>Sectoral value chain ...</td>
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<tr>
<td></td>
<td>Sectoral value chain n</td>
</tr>
<tr>
<td>Capability domain 1</td>
<td></td>
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<tr>
<td>Capability domain 2</td>
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<td>Capability domain 3</td>
<td></td>
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<tr>
<td>Capability domain 4</td>
<td></td>
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<tr>
<td>Capability domain ...</td>
<td></td>
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<tr>
<td>Capability domain n</td>
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</tbody>
</table>
Architecture and Dynamics of Industrial Ecosystems

- Diversification dynamics, within and across sectoral value chains, in the structured production space of an industrial ecosystem, follow three main patterns:
  
  - (i) diversification triggered by *similarities*;
  
  - (ii) diversification triggered by *complementarities*;
  
  - (iii) diversification triggered by *recombination/integration across capability domains*.

- Diversification may lead to *innovative industrial renewal dynamics* in mature industrial economies both in the form of the ‘emergence’ of new sectoral value chains, or the ‘transformation’ of the existing ones, for example when firms upgrade towards higher-value product segments.

- The ‘*decline*’ of an industrial ecosystem can be understood as a “transformation failure”, thus, the incapacity to govern the transition towards new innovative diversification trajectories.
<table>
<thead>
<tr>
<th>Capability domains</th>
<th>Sectoral value chain 1</th>
<th>Sectoral value chain 2</th>
<th>Sectoral value chain 3</th>
<th>Sectoral value chain ...</th>
<th>Sectoral value chain n</th>
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<tr>
<td>Capability domain 1</td>
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<td>Capability domain 2</td>
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<td>Capability domain 3</td>
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<td>Capability domain 4</td>
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<td></td>
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<tr>
<td>Capability domain ...</td>
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<td></td>
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<tr>
<td>Capability domain n</td>
<td></td>
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</tbody>
</table>

- **Complementarity**
- **Integration recombination**
- **Similarity**
<table>
<thead>
<tr>
<th>Capability domains</th>
<th>Distinctive clusters of resources and capabilities</th>
<th>Cross-sectoral value chains applications</th>
</tr>
</thead>
</table>
| Bio, food and agro-technologies | - Characterisation and selection of new raw materials, their quality and safety  
- Design and validation of equipment and plants for food processing and packaging  
- Agro-food process and product optimisation  
- Agro-food biological resource improvement and valorisation  
- Mechanic and functional augmented food  
- Improvement of the nutritional characteristics of food  
- Agro-food-specialised industrial equipment and mechanical plants  
- Food packaging, including innovative materials for packaging, quality and hygiene, environmental impact of packaging  
- Advanced plants and technique for food and drug packaging, including active packaging  
- Molecular traceability and traceability systems  
- Agro-food-relevant microorganism  
- Food quality, safety and health, including use of non-destructive analysis methods  
- Valorisation of typical productions  
- Assisted improvement platform for the seed industry  
- Agro food industry by-products and rejects value recovery  
- Dedicated energy crops and residual biomass in agriculture  
- Biomass evaluation mapping and modelling for energy uses  
- Energy conversion systems  | - Food and beverage industries  
- Suppliers of raw materials and semi-finished products  
- Producers of sensors and packaging materials  
- Seed industries  
- Mills  
- Ingredients and semi-manufactures  
- Fruit and vegetable consortia  
- Phytochemical product manufacturer  
- Packaging  
- Chemical industry  
- Rubber and plastic  
- Pharmaceutical industry  
- Machines and plants for the food industry  
- Waste treatment and disposal |
| Advanced materials | - Material sciences (all material application)  
- Development and characterisation of new materials  
- Design, processes, synthesis and characterisation on organic and inorganic and hybrid materials  
- Advanced materials, design and photonic applications  
- Advanced functional materials  
- Structured and/or composite materials for advanced applications  
- Surface treatments  | - Advanced manufacturing  
- Automotive machinery  
- Agricultural machinery  
- Automotive and transport  
- Electronics  
- ICT industry  
- Hydraulics  
- Industrial mechanics  
- Mechatronics for industrial and civil use  
- Machine tools  
- Packaging  
- Mechanical components  |

<table>
<thead>
<tr>
<th>Capability domains</th>
<th>Distinctive clusters of resources and capabilities</th>
<th>Cross-sectoral value chains applications</th>
</tr>
</thead>
</table>
| Mechanical systems and automation | - Polymers and injection moulding technologies  
- Metallurgy, corrosion and polymeric materials for the environment  
- Ceramics  
- High performance, functionally augmented and low-recycling-cost ceramic materials  
- Recycled materials technology  | - Industrial design for mechanics  
- Precision engineering  
- Mechanical design, prototyping and e-testing  
- NVH (noise, vibration, harshness)  
- x-tronics, automation, mathematical models  
- x-tronics, automation, logic models  
- x-tronics, actuators, control electronics, power electronics  
- x-tronics, hydraulic actuators  
- x-tronics, sensors  
- Automation, robotics and mechatronics: actuators and sensors  
- Virtual prototyping and experimental modelling of mechanical systems  
- Tracking and tracing of products and processes  
- Augmented and virtual reality  
- Collaborative design validation, digital mock up, virtual prototyping exploration and real-time simulation for the design of new products  
- Mechanical properties, in particular tribological (friction and wear), surface and multiscale coatings  
- Coating engineering for mechanics  
- Coating engineering at the macro–micro scale  
- Processing and nanofabrication  
- Configuration and management of integrated production systems  
- Industrial applications of materials and innovative technological processes  
- Machining technologies for the automotive and aeronautical sector  
- Fluid dynamics  
- Thermo – fluid dynamic, engines, car and vehicles  
- Thermo – fluid dynamic, machines and energy conversion systems  | - Advanced manufacturing  
- Automatic machinery  
- Agricultural machinery  
- Automotive and transport  
- Electronics  
- ICT industry  
- Hydraulics  
- Industrial mechanics  
- Mechatronics for industrial and civil use  
- Machine tools  
- Packaging  
- Mechanical components  |
<table>
<thead>
<tr>
<th>Capability domains</th>
<th>Distinctive clusters of resources and capabilities</th>
<th>Cross-sectoral value chains applications</th>
</tr>
</thead>
</table>
| ICT and embedded systems   | • Electronic components  
• Embedded systems  
• Software engineering and software architecture  
• Interoperability, protocols and standards  
• Automation and control  
• Algorithms, data and signal processing  
• Mechatronic systems and applications  
• Robotics  
• Integration in components and systems  
• Men-machine interfaces  
• Computer vision and pattern recognition  
• Sensor and monitoring/control systems  
• Information and communication systems and network infrastructure  
• Knowledge management and semantic-based systems  
• Cloud computing, mobile and pervasive computing  
• Internet of things  
• Bioinformatics | • Advanced manufacturing  
• Automatic machinery  
• Agricultural machinery  
• Automotive and transport  
• Electronics  
• ICT industry  
• Hydraulics  
• Industrial mechanics  
• Mechatronics for industrial and civil use  
• Machine tools  
• Packaging  
• Mechanical components  
• Food industry  
• Civil construction  
• Industrial construction  
• Chemical industry  
• Pharmaceutical industry  
• Biomedical industry  
• Logistics and transport  
• Multimedia  
• Public Administrations  
• Safety  
• Defence  
• Health services  
• Pharmaceutical-biotechnological  
• Biomedical and biomaterials  
• Nanotechnological  
• ICT  
• Cosmetics  
• Food industry  |
| Biopharma and medical technologies | • Biosensors  
• Medical devices  
• Drug delivery and quality by design  
• Drug discovery  
• E-care  
• OMICs and bioinformatics for ‘OMICs’  
• Pre-clinic trials  
• Diagnosis technologies  
• Development and pre-clinic validation of biological therapeutic agents (antibody drugs)  
• Personal health technologies  
• Therapy technology  
• Advanced therapies  
• 2D and 3D scaffolds  
• Regenerative medicine and tissue engineering in orthopaedics  
• Pharmaceutical innovation  
• Translational medicine, especially for innovative diagnosis and treatment of degenerative disease of the nervous and cardiopulmonary systems  
• Industrial applications of genomic and mitochondrial medicine  
• Biocompatibility, technological innovation and advanced therapies |  |

Source: Own elaboration based on several sources including ASTER sectoral and technology studies, High Technology Network data, and personal interviews with ASTER and companies in the ER ecosystem.
### Industrial Ecosystem Architecture and Diversification Dynamics: Emilia Romagna case

<table>
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<td>Sectoral value chain 1: Medical device</td>
</tr>
<tr>
<td>Capability domain 1: Bio, food and agro technologies</td>
<td></td>
</tr>
<tr>
<td>Capability domain 2: Advanced materials</td>
<td>Lean</td>
</tr>
<tr>
<td>Capability domain 3: Mechanical systems and automation</td>
<td></td>
</tr>
<tr>
<td>Capability domain 4: ICT and embedded systems</td>
<td></td>
</tr>
<tr>
<td>Capability domain 5: Biopharma and medical technologies</td>
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</tbody>
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**Fig. 4.** *The ER production space matrix and diversification dynamics: illustrative company cases*

*Source: Author*
The population/diversification of the industrial ecosystem

- variety of focal firms operating as system integrators, but also complementors, suppliers and specialist contractors (including knowledge-intensive business services [KIBS]) ‘joining up’ and ‘pollinating’ the industrial ecosystem

- Variety of diversification patterns along similarity, complementarity and recombination (also 4IR technology fusion)

- International companies strategies for nurturing the ecosystem:
  - promoting the spin-off and development of specialist contractors
  - Corporate governance restructuring/M&E, long term contracts etc.
Biomedical device firm network types

A flowchart showing network types for different sectors. The diagram includes arrows indicating firm linkage and subcontractors orchestration. The vectors of innovation are categorized as intrasectoral and intersectoral.

**Intrasectoral Vectors**
- $v_0$: Design
- $v_1$: membranes
- $v_2$: micro tubing
- $v_3$: sensors
- $v_4$: pumps

**Intersectoral Vectors**

**Firm Linkage**

**Subcontractors Orchestration**

**SPEC: Specialist Production & Engineering Contractor**
- Competency (technological, production operational/management, enabling)
- Combinations of competencies

**Design**
- Manufacturing (major assembly)
- Manufacturing (components, etc)

**Sales & Services**
Policy challenges in mature industrial economies

• The policy challenge of keeping the ecosystem along a trajectory of diversification and innovative industrial renewal is paramount.

• There are multiple factors which can lead to a “transformation failure” in the industrial ecosystem and result in its decline.

• Decline might be determined by the presence of structural holes in the production space; failures in developing closely complementary capabilities; failures in catching-up with emerging technologies; extractive governance models which do not support co-value creation processes.

• New tools for designing diversification strategies which take into account the complex architecture of the industrial ecosystem are needed.
Outline

• Analytical frameworks matter to visualise opportunities and develop innovative industrial renewal pathways

• Opportunities for diversification and innovative industrial renewal are often nested in the productive structure of industrial ecosystems

• Innovative industrial renewal can follow different sectoral and cross-sectoral pathways (increasingly cross-sectoral given digitalisation)

• Industrial restructuring and industrial policy alignment is critical, especially when innovative industrial renewal requires technology fusion

• Challenges of peripheral regions in the digitalisation era
Industry case 1, ER: Packaging machinery (diversification in higher value product-segments)

• The world packaging machine industry accounts for a total turnover of over 33 billion dollars and is composed of four main product segments: Food, Beverage, Personal Care, and Pharmaceutical packaging.

• Over the past 15 years the industry has grown at a cumulative rate of 15%, with the Pharma value-product segment growing at over 20%. Together with Baden-Württemberg and Hessen in Germany, Emilia Romagna (ER) in Italy is the regional industrial system with the highest concentration of firms producing automatic packaging machines.

• The industrial ecosystem of the Emilian packaging valley is mainly composed by SMEs operating as subcontractors, however four global leaders are also located in this area: IMA, GD, SACMI and Marchesini.

   Among them, IMA has been the most successful in shifting towards the highest value-product segment of the packaging industry – i.e. Pharma.
The **IMA** case: from Food to Pharma

### CUSTOM DESIGNED COMPONENT SUPPLIERS

- **NON EU**: 0.4%
- **Rest of the EU**: 3.6%
- **HQ in the Province of Bologna**: 57.8%
- **Rest of Italy**: 24.4%
- **Rest of Emilia Romagna**: 13.8%

- **Suppliers active for more than 7 years**: 65%
- **Suppliers active for 1.2 years**: 26%
- **Suppliers active for 3.7 years**: 9%

### DURATION OF THE RELATIONSHIP WITH CUSTOM DESIGNED COMPONENT SUPPLIERS

**WORLD**

- **24 plants**
- **27 branches**
Industry case 1, ER: Packaging machinery (diversification in higher value product-segments)

Packaging machines have evolved, over the past two decades, from an architecture based on mechanical components, into a combination of mechanical transmissions, robotics, interfacing electronics, and control software. This modularity prompting the need for new production capabilities, pave the way for a totally integrated mechatronic platforms.
Industry case 1, ER: Packaging machinery \textbf{(diversification in higher value product-segments): Technology cycle}

- strong technology dynamism reaching two peaks in 1992 and 2004

\begin{itemize}
  \item at product segment level, we observe \textbf{two very different patterns for F&T and Pharma}. Technology applications in the F&T segment remain fundamentally stable over the entire period, with on average 60 patents applications per year. E
\end{itemize}
Industry case 1, ER: Packaging machinery (diversification in higher value product-segments): technology transition

- we can identify the technology cycles for each product segments (by extracting the standardised cyclical components of the patents applications patterns and removing the segment specific trends)
- we track the transition from mechanics to mechatronics (adoption and integration in packaging machines of automatic control systems based on electronics, information and communication technologies): this technology transition opened higher value-product segment opportunities resulting from the increasing operational speed and configuration flexibility of the packaging machines, the full traceability of the packaged products and the possibility of integrating and standardising entire packaging production lines
Industry case 1, ER: Packaging machinery (diversification in higher value product-segments): Technology transition and organisational reconfiguration

• What IMA did to diversify into higher-value product segments?

**Technological transition**

IMA is today’s the world leader in the production of packaging machines and integrated packaging lines for the Pharma segment with a world market share of 16%

**Organisational reconfiguration:** internal structure and its strategic relationships with the ER regional production system

- Internationalisation, in two stages
- Acquisition of complementary capabilities
- Organisational integration and consolidation of local suppliers
Industry case 1, ER: **Packaging machinery (diversification in higher value product-segments)**

### The role of the Public Sector:
- 3 phases
- 2 axes

### Key lessons:
- Continuous policy/institutional re-alignment
- Multi-level interventions (IMA, first, second tier suppliers) for industrial ecosystem development
High Technology Network – ASTER
Technology platform based PTIs
Outline

• Analytical frameworks matter to visualise opportunities and develop innovative industrial renewal pathways

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• Innovative industrial renewal can follow different sectoral and cross-sectoral pathways (increasingly cross-sectoral given digitalisation)

• Industrial restructuring and industrial policy alignment is critical, especially when innovative industrial renewal requires technology fusion

• **Challenges of peripheral regions in the digitalisation era**
Digitalisation
Evolutionary transition or evolutionary disruption?

Source: Author, see IDR 2020
Digital production technologies
Evolutionary transition or evolutionary disruption?

Digital production technologies: backbone of productivity and sustainability

• result from incremental changes in the hardware of these machines, as well as their software – thus, their functionalities and data use in a cyber-physical space – and their connectivity – thus, their integration with other production technologies (and products).
Challenges in digitalisation

- Technology absorption, effective deployment and ‘capability threshold’
- Production system retrofitting and integration
- Basic and digital infrastructure
- Technology diffusion, 4IR islands and the digital capability gap
- Endogenous asymmetries in technology access and affordability
Summing up

• Analytical frameworks matter: Industrial ecosystem
• Opportunities for diversification and innovative industrial renewal
• Innovative industrial renewal: sectoral and cross-sectoral pathways
• Industrial restructuring and industrial policy alignment
• Challenges of peripheral regions in the digitalisation era