# Building the layers of a manufacturing taxonomy: how 3D printing is creating a new landscape of production eco-systems and competitive dynamics

**Rieple, A., Kapetaniou, C., Pilkington, A., Fransden, T. and Pisano, P.**

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# Building the layers of a manufacturing taxonomy

## How 3D printing is creating a new landscape of production ecosystems and competitive dynamics

Alison Rieple (University of Westminster)

Chrysta Kapetaniou (University of Westminster / LSE)

Alan Pilkington (University of Westminster and Copenhagen Business School)

Thomas Fransden (Copenhagen Business School)

Paola Pisano (Turin University)

# The problem

- Recent innovations in 3D printing technologies and processes have influenced how products are designed, built and delivered.
- However, there is a significant gap in our knowledge of how 3D printing is impacting on manufacturing eco-systems and competitive dynamics in different industries and contexts
  - “a granular understanding of the socioeconomic consequences of 3D printing lags activity” (Ford et al., 2016).
- This paper addresses this by developing a taxonomy of firms based on their use of 3D printing

# Methodology

- Based on systematic review of secondary data
  - Newspaper articles, websites, industry commentaries, academic papers
- 20 Illuminatory cases

# 3D printing

- Process of joining materials to make objects using digitised model data
- Original use for prototyping and model making
- Now more widely used in manufacturing of end products
- Benefits include:
  - Supply chain efficiencies
  - Shorter design processes
  - Reduced time to market
  - Move from mass manufacturing to mass customization
  - Monetizing of the long tail
  - Sustainability benefits
    - Reduction of waste

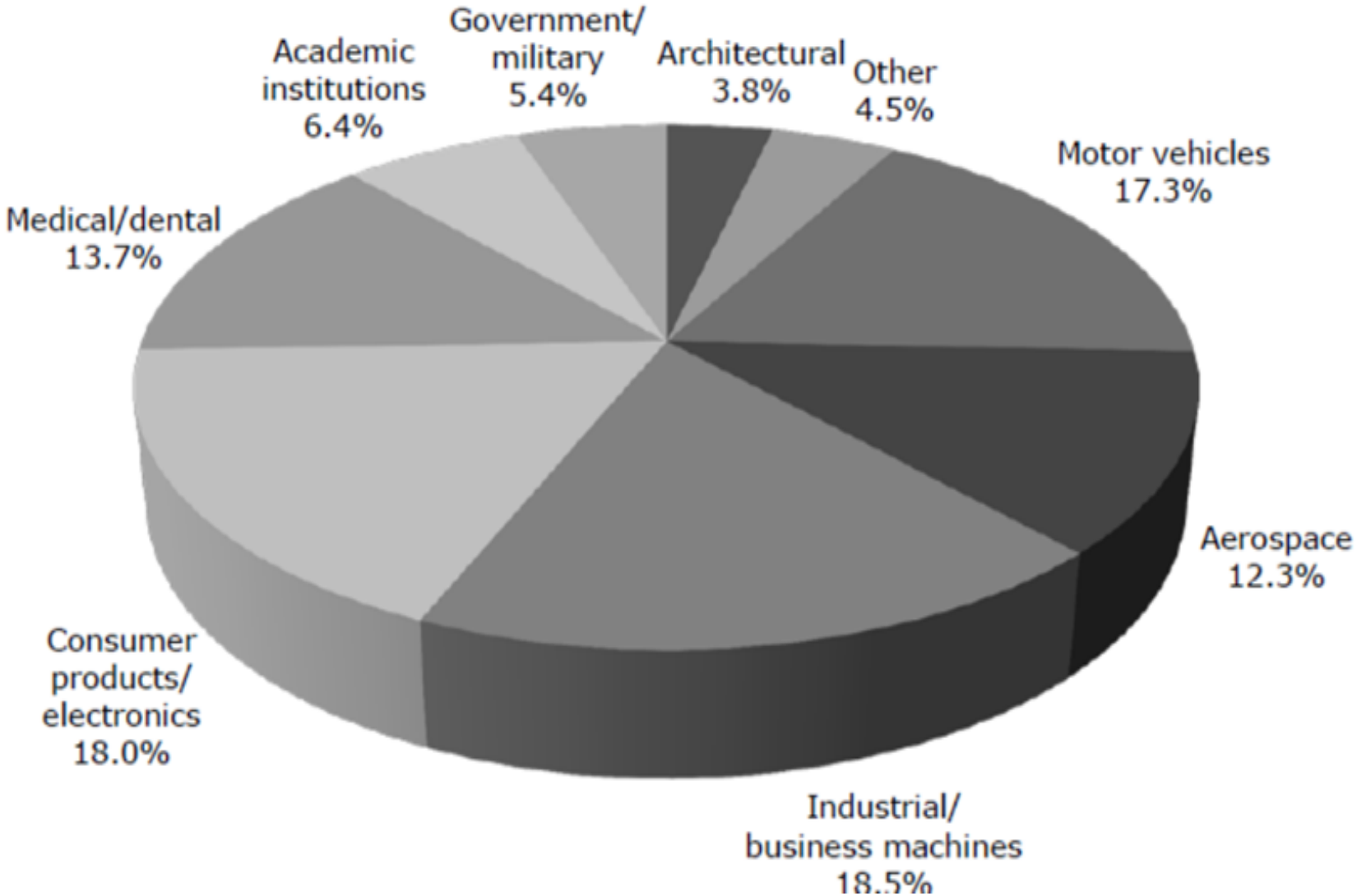
# 3D’s potentially disruptive effect on manufacturing ecosystems

- Potentially transforming many manufacturing sectors’ business models
  - location of manufacturing,
  - new materials,
  - new supply chains,
  - new cost and pricing structures,
  - much greater potential for co-development
    - disintermediation
    - Maker movement

# Current generic limitations of 3D printing technologies

- Raw materials' reliability
  - new suppliers who are inventing the materials as they go along
- Limitations in the size of products possible
- Problems in scaling up production

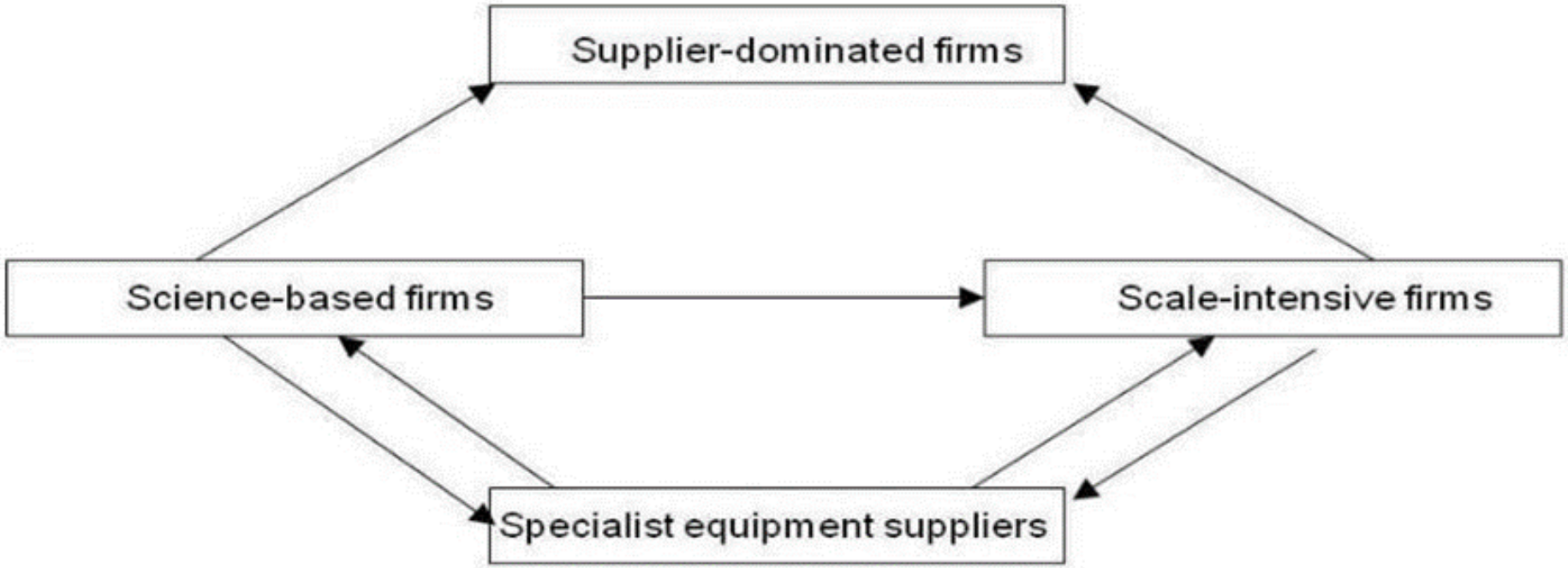
# Use of 3D printing in different sectors (Wohlers 2014, p.18 )



# Industrial taxonomies

- Pavitt (1984)
- Castellacci (2008)
  - Help to conceptualise typical behaviours in different sectors
  - Draw out implications for competitive strategies and dynamics
- Pavitt
  - Focused on innovation and dominance
  - Castellacci added to this service- manufacturing sectors external sources and open business models

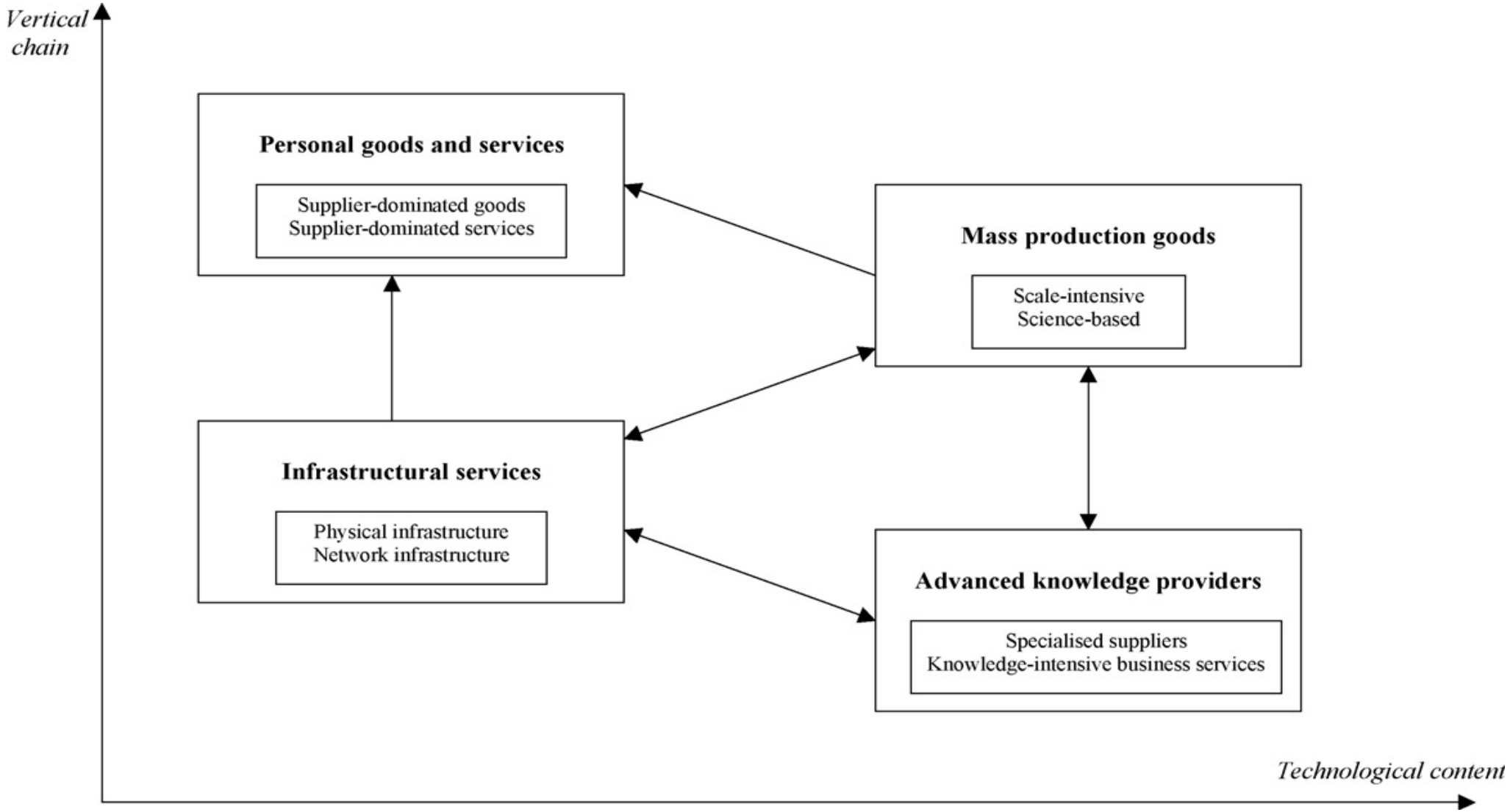
# Pavitt's taxonomy showing technological linkages



# Pavitt Taxonomy of Innovation Patterns (adapted from Kristensen 1999)

| Sector type/ variables | Supplier-dominated (SD) | Scale-Intensive (SI) | Science-Based (SB) | Specialised suppliers (SS) |
|---|---|---|---|---|
| **Firm size** | Small firms | Large firms | Large firms | Small firms |
| **Type of innovation** | Processes | Processes | Mixed products and processes | Products |
| **Locus of innovation** | External | Production | R&D departments | Decentralised |
| **Means of appropriability** | Tacit knowledge | Tacit knowledge and entry barriers | Patents and entry barriers | Tacit knowledge/ reputation |
| **Competitive parameter** | Price | Price/ quality | Performance/ quality/ price | Quality/ performance |

# Castellacci's taxonomy



# Three major components of the new taxonomy

- inductive approach enabled 3 categories to emerge from the data
  1. the uses and applications of 3D printing
  2. the level of customisation
  3. the level of competitive turbulence.

# Our results: the main users of 3D printing

- consumer products,
  - clothing/textiles
  - artistic products such as jewellery
- consumer electronics,
- automotive,
- aerospace,
- medical/dental,
- industrial/business machines,
- material suppliers
- Knowledge Intensive Business Services (KIBS)
  - software development, design, and online platforms for the application of 3D printing

| Industry | Sector | Uses and applications of 3D printing | Customisation | Competitive Turbulence |
|---|---|---|---|---|
| **Supplier-Dominated** | Wearing apparel | Customised Products | Co-creation and Personalisation | High |
| | Jewellery, bijouterie and related articles | | | |
| | Footwear | | | |
| **Scale -Intensive** | Motor vehicles | Specialised components for production | Mass Customisation | Low |
| | | Spare parts and components | None | Medium |
| **Science-Based** | Air and spacecraft and related machinery | Approved components | None | None |
| | | Prototype jet engine parts | None | None |
| | | Specialised components for production | None | None |
| | Medical and dental instruments and supplies | Customised orthoepedic implants and prosthetics | Personalisation | Medium |
| | Pharmaceutical products | Approved drugs | Personalisation | Medium |
| | Consumer electronics | Production tooling | Personalisation | Medium |
| | | Low volume customized products | Personalisation | Medium |
| **Advanced Knowledge Providers** | Knowledge Intensive Business Services | Consulting, Software, Design | Enabling opportunities | Low |
| | Specialized suppliers | 3D printing materials and equipment | Enabling opportunities | Medium |

# Supplier dominated

- Implement technologies developed outside the firm
- May not invest themselves in R&D
- Improvement rather than radical change
- Rapid prototyping ethos applied to end products

- Current challenges
- Standard of materials and supplies
- Lack of choice of suppliers
  - Supplier power likely to increase

# Scale-intensive firms

- Invest heavily in R&D
- Close cooperation with specialized suppliers
- Not yet achieved scalability in end products
- Using 3D printing to create tools and components
- Large potential cost savings
  - But loss of profits from spare parts as they can be produced by other printers

## Current challenges

- 3d printing not yet able to speed up mass production times

# Science-Based firms

- Internally-generated new knowledge
- Collaboration with institutions such as universities
- 3d printing opened up new possibilities
  - Aerospace, defence, shipping etc
  - Huge cost and performance possibilities
  - Geographical benefits
    - Bypass international import duties
    - Parts for ships can be made at sea
  - Customizable products

- Current challenges
  - Unreliability of raw materials
    - 3D printers inability to cope with this (as normal manufacturing techniques can)
  - Size limitations
  - Lock-in to certain suppliers
  - Certification and reputation risk problems

# Advanced Knowledge Providers and Knowledge Intensive Business Services (KIBS)

- Heterodox sector
- 3D developers as well as 3D users (architects etc)
- Significant technological capability
  - Suppliers of know-how to other firms
- Provision of online design libraries

- Current concerns
- IPR issues
- Crowd customisation
  - Co-development
  - Maker movement

# Final thoughts

- 3D printing will not fulfil the hype in all sectors
  - How many 3D printing shops do you have on your high street?
  - Too many intermediary roles  and supply standards to be resolved
  - Scale-intensive industries likely to use 3D printing selectively
- 3D printing allows (in theory) co-creation in most sectors
  - But the role of designer, IPR and skills of end users is yet to be resolved
- 3d printing more disruptive in some industries than others
  - Supplier-dominated firms likely to be worse affected

THANK YOU