Knowledge transfer to 'non high-tech' industry and services: The case of Additive Manufacturing adoption by the molds sector

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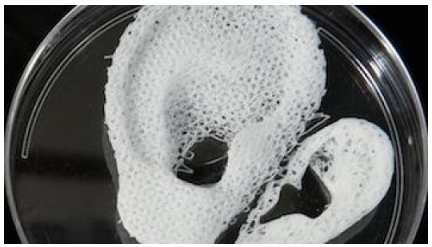
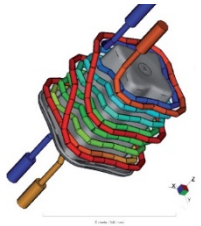
Stimulating Knowledge Transfer: Challenges and Policy Responses

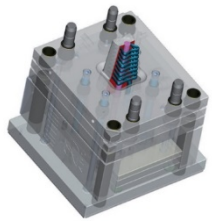
Additive manufacturing creates objects, layer-by-layer, from a digital design

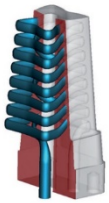
Polymer Additive manufacturing (PAM)



Metal Additive manufacturing (MAM)







Uses	Prototyping, Consumer Products	Final components
First commercialized	1987 (3D Systems, USA)	1994 (EOS, Germany)
Cost	Low-end (since 2009): $100s High-end: $0.5-$1M	$0.5-1M

Pictures from: *Henriques and Osório, 2002;*eos.info;carbon3d.com; Wake Forest Univ.; ge.com; *initial.fr; additivemanufacturing.com*

Comparative case study:
Metal (MAM) vs Polymer (PAM) additive manufacturing

Portugal

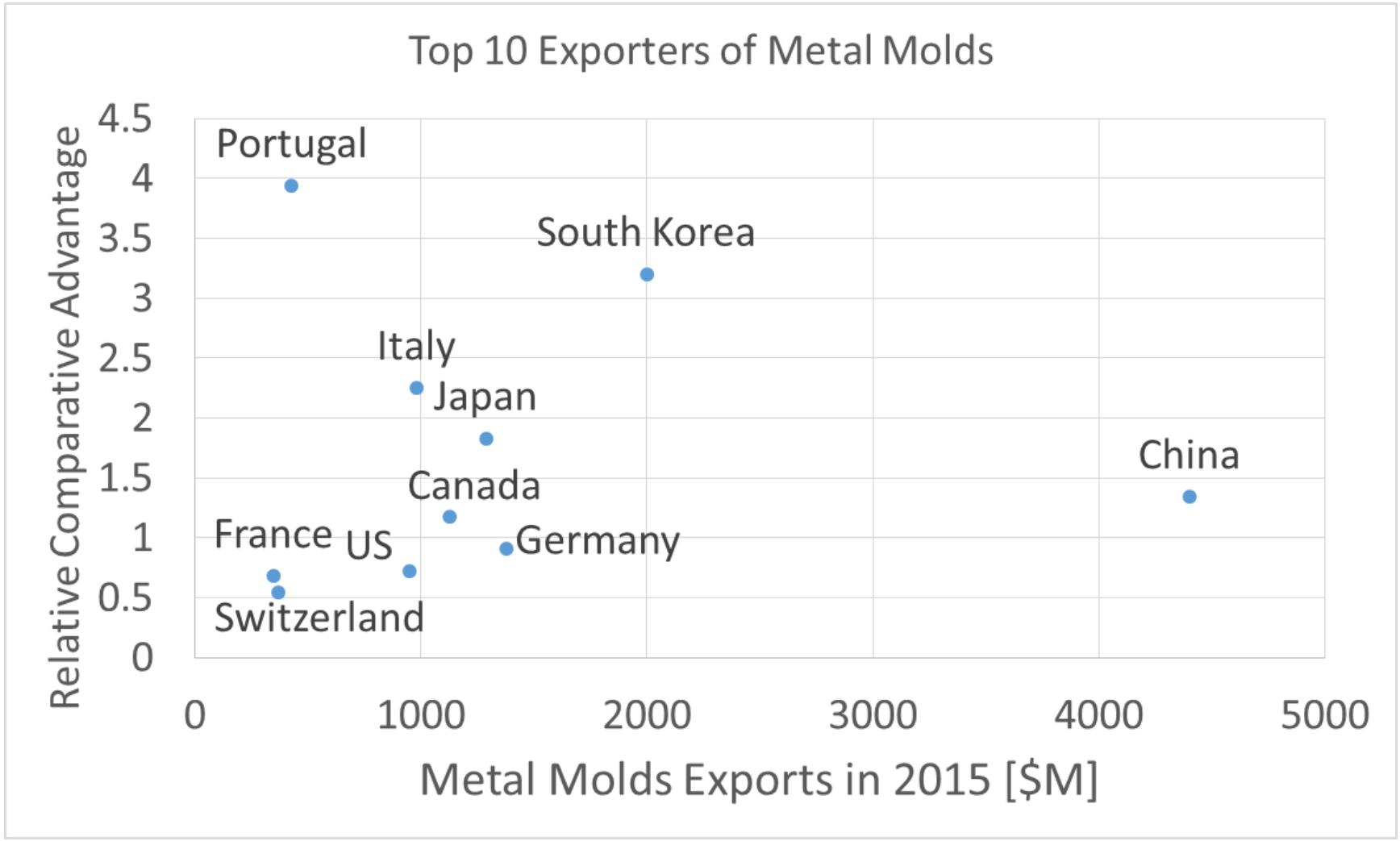
- 10M people
- Public funding for innovation comes from EU funds
  - 5 NUTS II regions
  - Lisboa "more developed" since 2005
  - Centro and Norte "less developed"
- 2 molds clusters

Reference: Bonnín Roca, J., Vaishnav, P., Morgan, M. G., Fuchs, E. & Mendonça, J. (2017). Technology forgiveness to institutional instability: adoption of polymer and metal additive manufacturing in a technology follower nation. *Working Paper*

Comparative case study:

Metal (MAM) vs Polymer (PAM) additive manufacturing

Portugal molds industry: globally competitive, PAM/MAM pioneer



Source: UN Comtrade

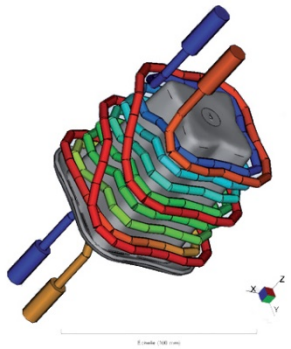
Why have PAM and MAM had such different level of adoption?

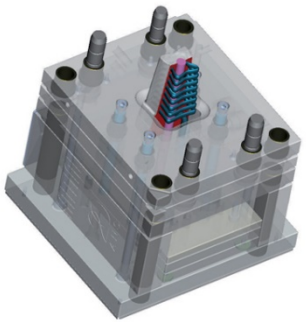
PAM

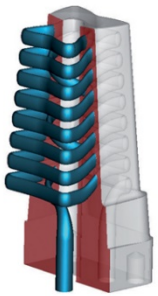
- used for prototypes
- Widespread (+100 machines)

MAM

- improves 10-20% performance
- modest adoption (<10 machines)







Source: Henriques and Osório, 2002

Source: initial.fr

Two technologies, different stages of development, uncertainty

	PAM	MAM
Capital investment	Low-end: <$1,000 High-end: $0.5-1M	High-end: $0.5-1M
Expertise (availability knowledge workers)	Many learning opportunities	Low
Stakeholder dynamics	Many small players	Large companies and universities
Incumbent technology	Costly handcrafted prototyping	Reliable CNC
# of constituents and interactions	Lower	Higher
New measurement techniques required	Yes	Yes
Testability during intermediate phases of production	Not yet	Not yet
Learning by using	Low	High (Corrosion, fatigue)

	PAM - Early Growth and Transition to High-end applications	MAM - Early Instability and Stagnation
Machines	• 1992: First SLA • 1997: SLS & LOM • 2000: 9 machines (2 FDM) • **2016: 100+ machines**	• 1997: First DMLS • After 2011: Machines at companies • 2012: DMLS for research • **2016: 7 machines**
Institutions	• 1992: Start in Lisbon • 1997: Extend to rest of country • 2005: TTO with SLA shut down • 2007: PAM research center • 2011: PAM manufacturer • 2016: DONE lab	• 1997: Start in Lisbon • 2006: National Lab shut down • **2006-12: No MAM research** • 2016: DONE lab
Projects	• 1990: First EU project • 1994: First PT project • 1997: National PPP • 1997-2016: **Continuous work, transition to high-tech applications in biotech**	• 1997-2006: PT projects • 1999: EU consortia RAPTIA (no continuity) • **2007-2014: No projects** • 2014: Portuguese Additive Manufacturing Initiative

Know-how: PAM democratized, MAM scarce

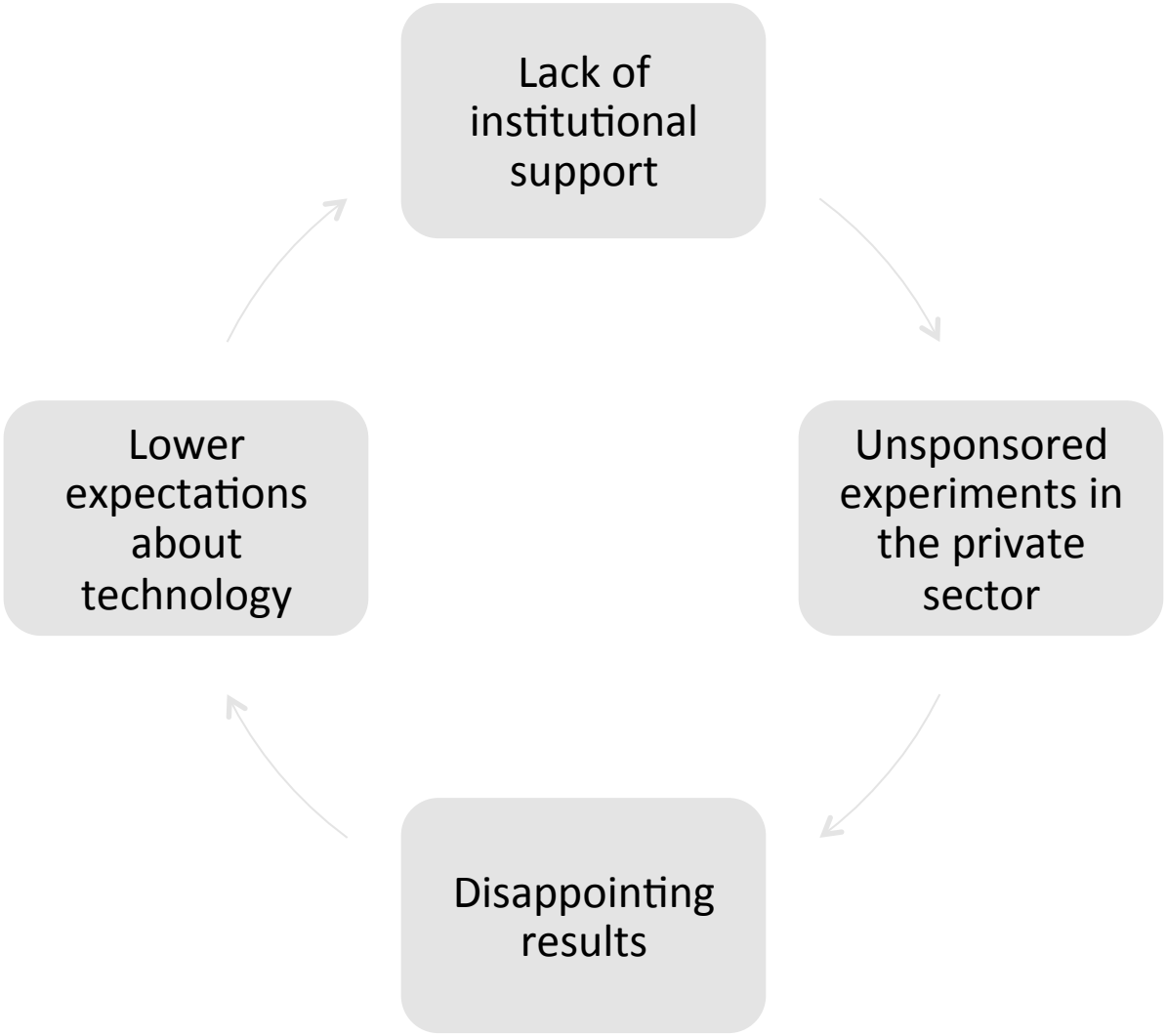
PAM

- Initially acquired through EU-wide projects
- Expanded across the country
- Critical role of **technology center**
- Now: 'Democratization' with low-, mid- and high-quality machines
- Training offered by companies, at universities and free online material
- Now: No need for own investment, wide variety of suppliers of PAM parts

MAM

- Initially acquired through EU-wide projects, but destroyed
- Concentrated in molds region
- Inactive technology center
- Only high-end equipment, less accessible
- No opportunities for formal training, little research
- Few local suppliers, quality issues
  → Increased caution

Lack of legitimation may lead to technology lockout



Findings: EU funding instruments shift towards small and medium sized entrepreneurs – MAM has fewer small, entrepreneurial firms than PAM

FP7 (2007-2013)

- Projects required at least:
  - 3 different SMEs, from 3 countries
  - 2 "Research and Technology Development" performers

Horizon 2020 (2014-2020)

- Single firms may apply
- Priority: fast-growing firms
- EU enlargement towards Eastern Europe
- Portugal success rate fell from ~18% to ~13%

- Traditional sectors not a priority under the new program
- PAM more used by entrepreneurs than MAM!

Sources: European Commission, 2016, 2015, 2007

Key observations

- Underinvestment in MAM could mean a loss of competitiveness in the long term.
- The Portuguese higher education system has neither enough equipment nor know-how to supply graduates with MAM-related skills.
- Portuguese firms and intermediary organizations reluctant to invest in MAM.
- Current structure of EU Structural Funds imposes severe constraints for the promotion of emerging technologies.

Policy recommendations

- Promote the creation of multisector public-private consortia to share equipment and accelerate the awareness of MAM's potential nationwide.
- Increase scope of existing international partnerships to access world-class MAM skills.
- Renegotiate the conditions of the Structural Funds for the next Framework Programme, to achieve flexibility to promote MAM in Portugal or create a national pool of funds for the promotion of technologies such as MAM which could be considered 'strategic'.

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