



# UNIVERSITÀ DI BRESCIA

## LABORATORIO RISE

### Research & Innovation for Smart Enterprises

Installed Base Information Management in the  
Servitization of Manufacturing: a Knowledge Management  
Perspective



# DISCLAIMER

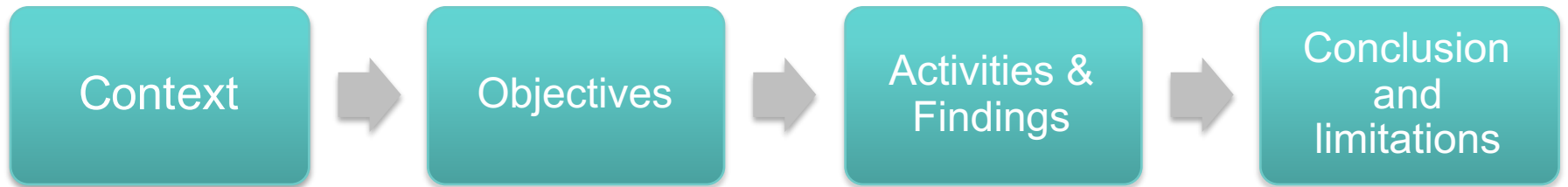
This document is authored by **Andrea Alghisi** of the Supply Chain and Service Management (SCSM) Research Laboratory of the University of Brescia (Italy).

The intellectual property of this document and of its contents belongs to the SCSM Research Laboratory.

This document or any of its parts may not be used, reproduced or diffused without the express written permission of the authors.

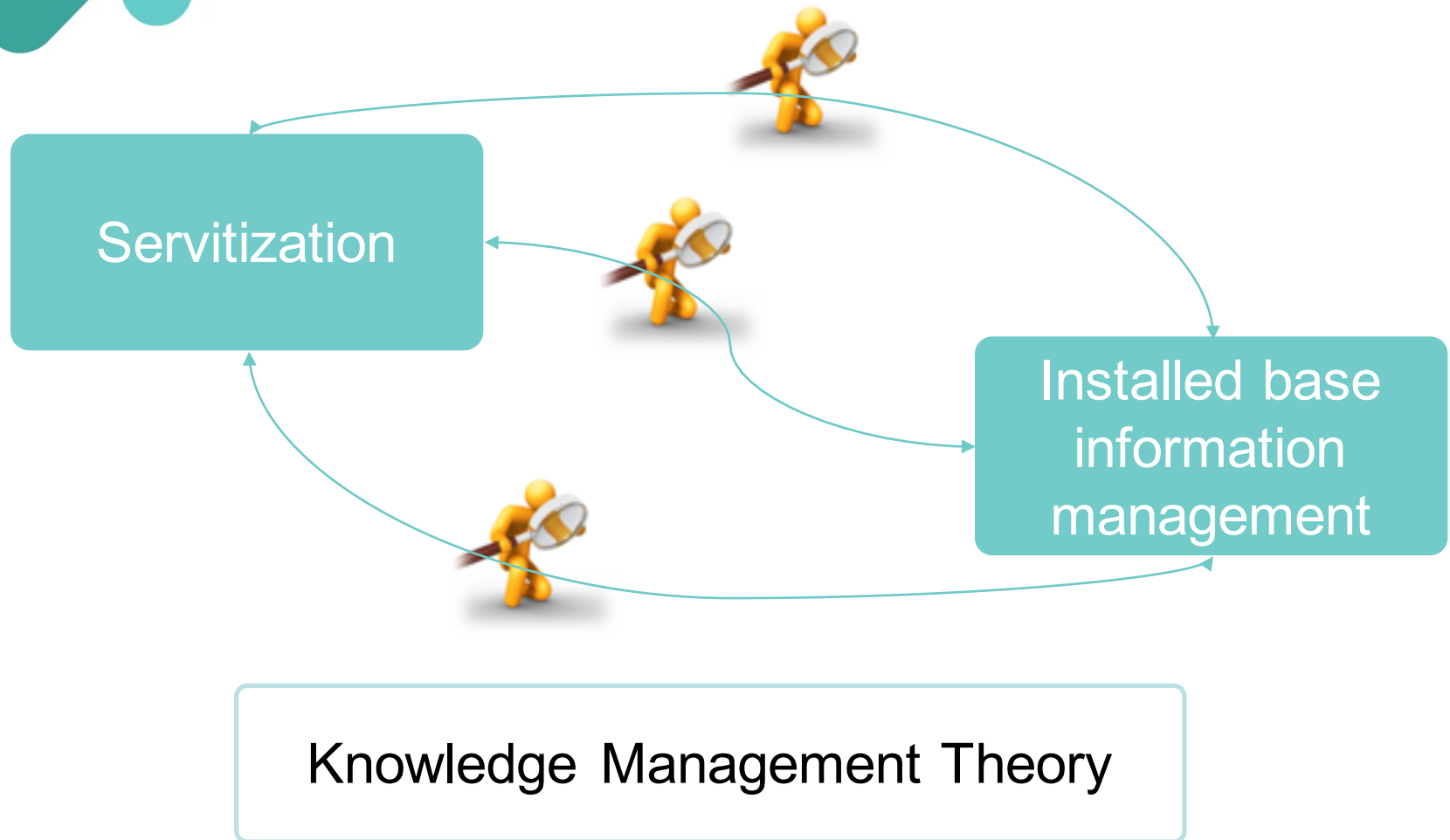


# AGENDA





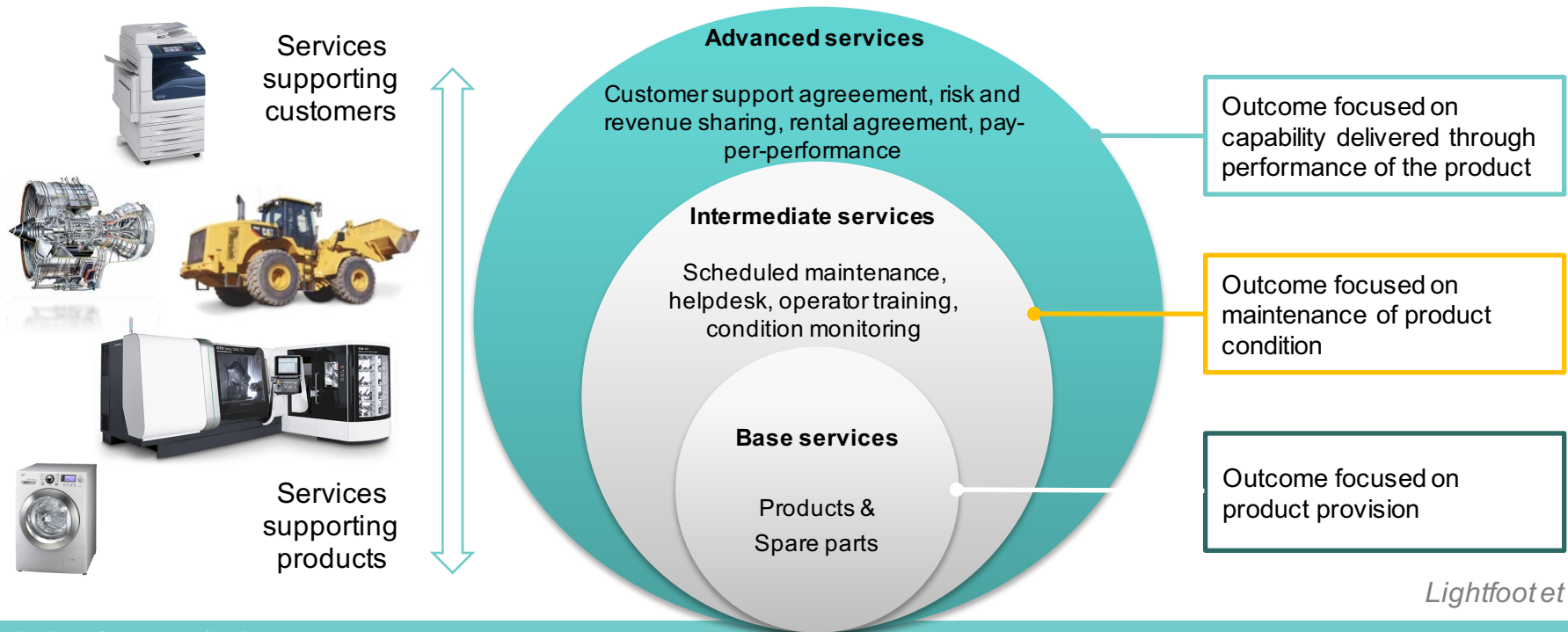
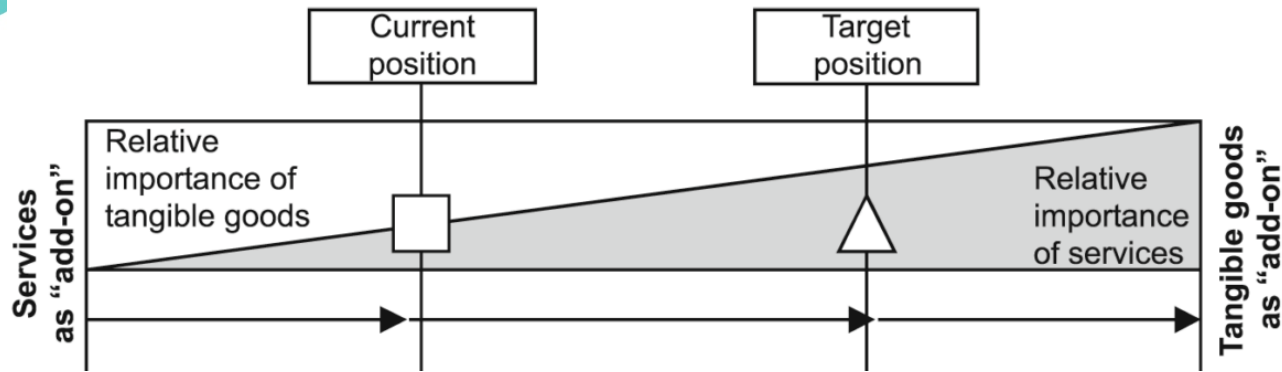
# The research setting





# What is Servitization?

*Adapted from Oliva & Kallenberg 2003*



*Lightfoot et al. 2013*



# Servitization benefits

## Marketing benefits

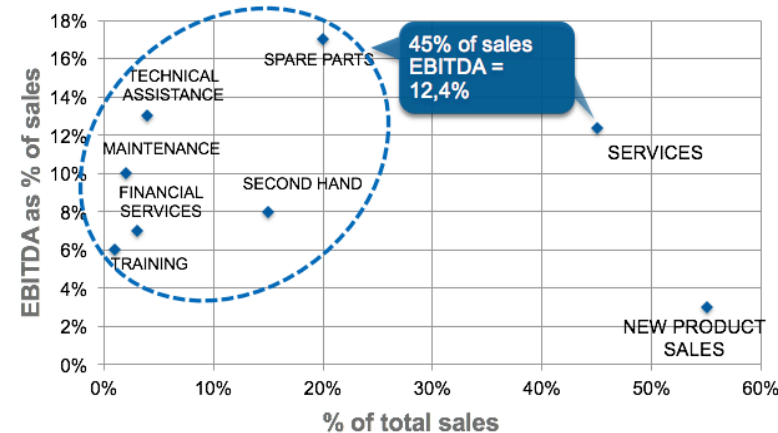
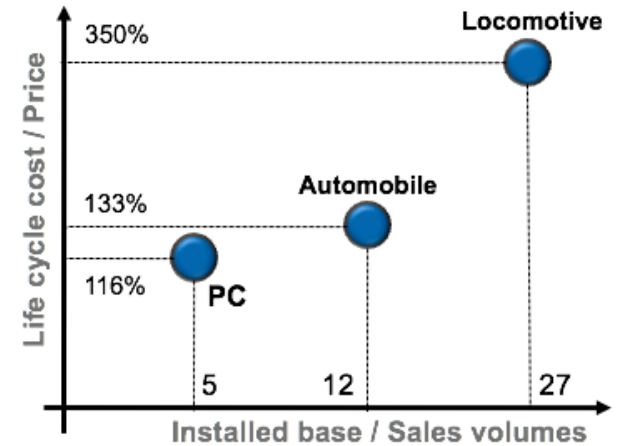
- ▶ Augmenting the product offering
- ▶ Intensity of customer relationship
- ▶ Lock-in effect for customers
- ▶ Long-term customer relationship (strategic partnerships)

## Strategic benefits

- ▶ Differentiation opportunities
- ▶ Comparison of offerings is more complex
- ▶ Collaborative innovation between customer and supplier
- ▶ Services as entry barrier for competitors
- ▶ Service competencies more difficult to imitate

## Financial benefits

- ▶ Higher margins (product: -1% to 3%; services: 5% to 20%)
- ▶ Stable source of revenue
- ▶ High installed base
- ▶ Size of the service market (service market 2 to 10x bigger than product market)

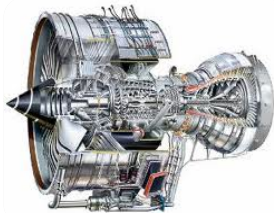




# The role of Information Management in Servitization: R-R example



Rolls-Royce



Large volumes of real time data produced by engine sensors are transmitted via Satellite to a control center where the data can be automatically stored, retrieved and then analyzed using appropriate algorithms and product experts to establish asset state and trends. This information set can be used to generate advanced warning of potential problems and enables the scheduling of materials and/or resources to undertake any necessary maintenance/repair activities

## Operations

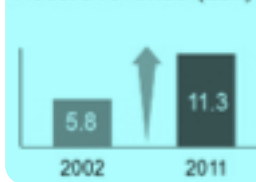


- Reduction of operational and maintenance cost
- Field service scheduling optimization
- Reduction of MTTR and MTBF

## Strategy

- Introduction of a new and innovative business model
- Disruptive shift of the revenue model (from selling engine to selling hour of functioning)
- Risk and responsibility shift from the user to the manufacturer

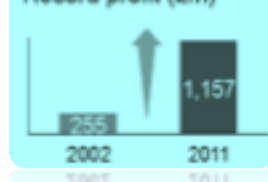
Record revenue (€bn)



Record order book (€bn)



Record profit (€m)

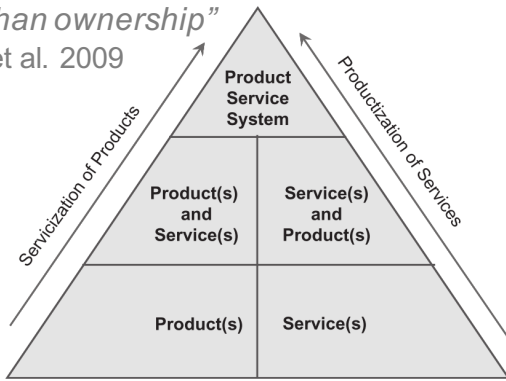




# Academic interest in Servitization...and installed base information

*"Innovation of an organisation capabilities and processes, to better create mutual value through a shift from selling product to selling Product-Service System values asset utilization rather than ownership"*

Baines et al. 2009



Number of journal papers published on servitization per year



Oliva & Kallenberg

Allmendinger & Lombreglia

Ala-Risku

Kowalkowski

Baxter et al.

Holmstrom et al.

Uлага & Reinatz

Lightfoot et al.

Nemoto et al.

McFarlane & Cuthbert

Ramanen et al.

Grubic

Baines & Lightfoot

Baines & Lightfoot

Roy et al.

Biege

*"Acquiring **strategic customer data** is a necessary though not sufficient condition: Manufacturers still must determine how to translate these data into a source of **new revenues** and/or an opportunity to **provide existing offerings at lower costs**"*

*"A **model/framework for capturing information** is important in order to ensure consistency, quality and effectiveness of operations."*

*"Application of existing and developing **technologies** (sensors, signal processing, ICT) can be used to **support the effective and efficient delivery of product-centric services**"*

*"The most common approach is to utilize the **service knowledge** from products to improve the **design and manufacture and associated services**"*

*"...this requires a new set of skills within the service organization and **information gathering capabilities to determine risk better**"*

*"If you're like many product-centric companies, you're scrambling to grow your revenues from services. The best ways begin with making the **products themselves smarter.**"*





## Definitions

### Installed Base

*“the term installed base is used as a collective noun for currently used individual products sold or serviced by the focal company”*

(Ala-Risku, 2009)



### Installed Base Information

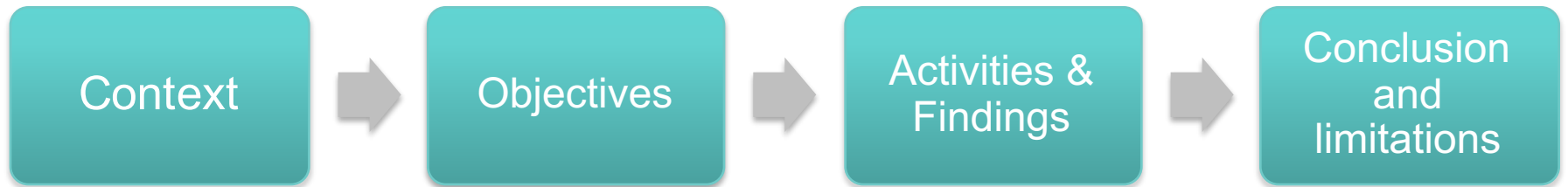
“All technical and commercial data related to installed base and needed for operation or optimization of industrial services”

### Installed Base Information Management

“The set of practices that companies adopt in order to collect, analyze, use and share data concerning installed products and their utilization, and customers”

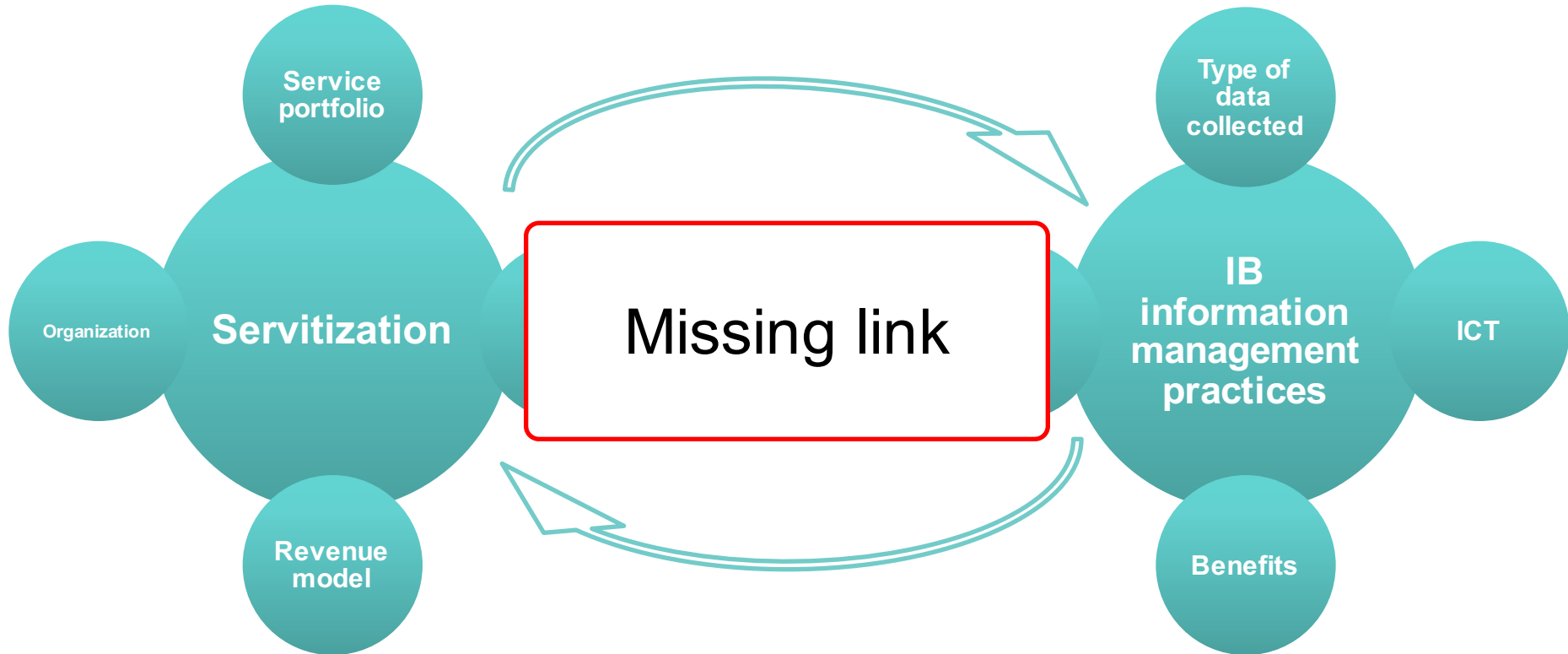


# AGENDA





# Research gap





# Research design

## Research questions

### RQ1

*What are the installed base information management practices that can support a product-service integrated offering?*

### RQ2

*How can the role of installed base information in the servitization processes be analyzed through the knowledge management theoretical approach?*

### RQ3

*How should a servitizing firm configure its knowledge management practices?*

## Research methodology

Literature review

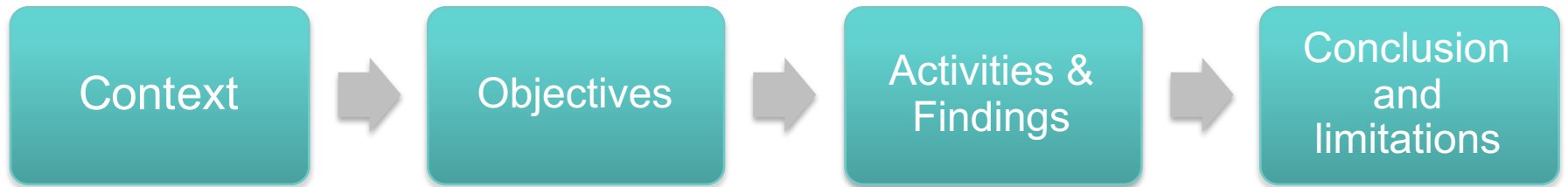
Survey

Case studies



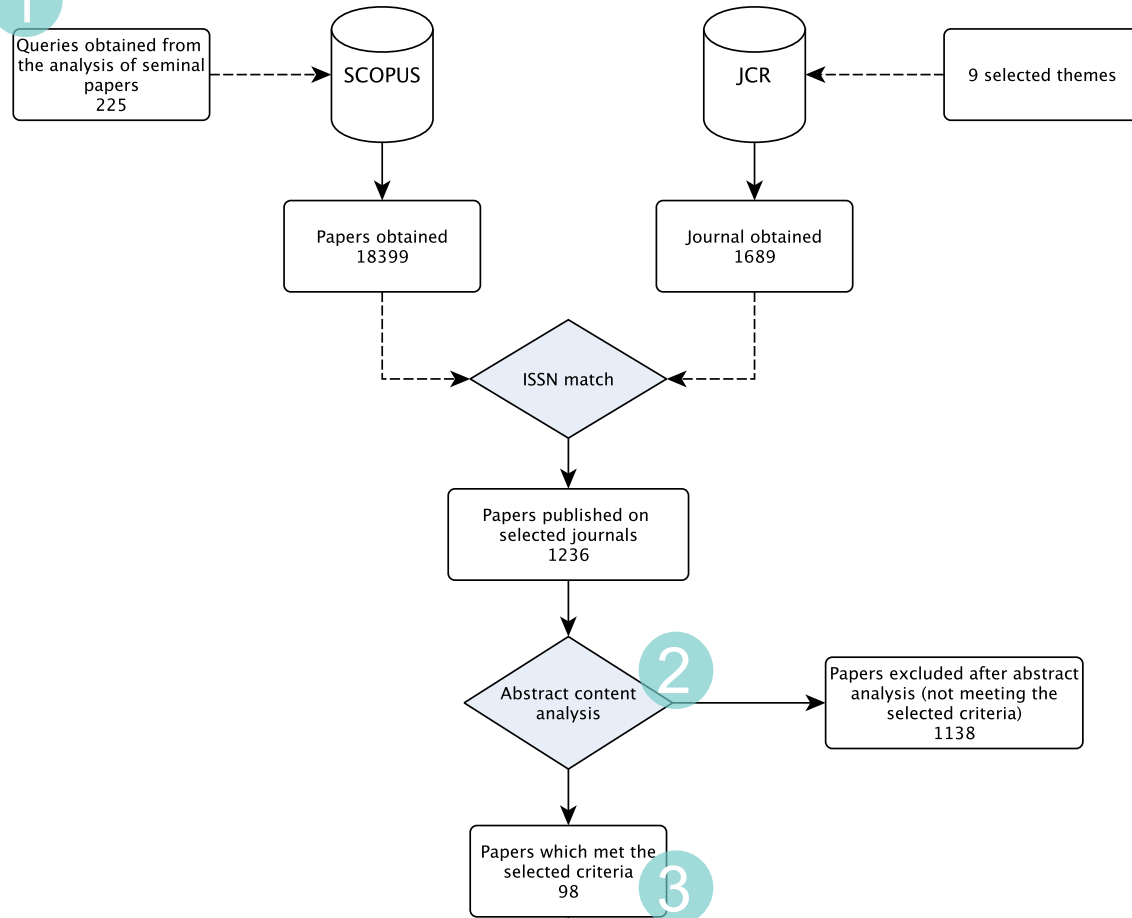


# AGENDA



# Extensive literature research and analysis

1



1

Two set of keywords extracted during the analysis of seminal papers

**SET 1**

PSS or Product-service system  
 Servitization  
 Product-service  
 Service + manufacturer  
 Service contract + manufacturer  
 Service network + manufacturer  
 Service development + manufacturer  
 Quality of service + manufacturer  
 Service level agreement  
 Spare parts  
 Maintenance  
 Maintenance contract  
 Condition base maintenance  
 Prognostic  
 Health management

**SET 2**

Installed base  
 Information  
 Information management  
 Information requirement  
 Value of information  
 Intelligent product  
 Smart product  
 Data management  
 Data analysis  
 Wireless sensor network or WSN  
 RFID  
 Internet of things  
 Product lifecycle management or PLM  
 Product data management or PDM  
 Asset management

2

Selection made with a set of 10 criteria obtained from the reading of seminal papers

3

Analysis of the paper using a preliminary framework developed from seminal papers



# Extensive literature research and analysis – Results

RQ1

RQ2

RQ3

		# of papers addressing the topic
<b>Installed Base</b>	Data Exploitation	24
<b>Information</b>	Data Analysis	11
<b>Management Process</b>	Data Collection	10
	Architecture design	3
<b>Installed Base</b>	Methods and models	23
<b>Information</b>	Technology (hardware)	22
<b>Management</b>	Information systems (software)	10
<b>Aspects</b>	Business model definition	6
	Types of installed base data/information	5
	Customer involvement / Co-creation	3
<b>Impacted Layers</b>	Strategic layer	32
	Operational layer	9
	Tactical layer	4
<b>Impacted Aspects</b>	Maintenance management	14
	Service engineering/NSD	8
	Delivery process design	4
	Service contract	4
	Cost estimation	3
	Spare parts management	2
	Performance management	2



# Survey – Sample

RQ1

RQ2

RQ3

- ▶ Web-based **exploratory** survey with both closed and open questions sent to **419 capital goods manufacturers** operating in Italy.
- ▶ Hit ratio = **19%**

Sectors	Number of respondents	Average turnover 2011 (.000) [€]	Average number of employees 2011
Machine tools	30	€ 42.502	157
Packaging machines	16	€ 45.257	161
Automation systems	8	€ 20.884	78
Other machines	8	€ 11.977	28
Textile, wood and ceramics machines	7	€ 69.987	216
Foundry machines	7	€ 16.398	66
Industrial plants	5	€ 50.166	197
<b>Sample</b>	<b>81</b>	<b>€ 42.190</b>	<b>148</b>





# Survey – Constructs, variables and measures

RQ1

RQ2

RQ3

Constructs	Variables	Measures
Service orientation (SO)	SO_1 = SBU Service nature  SO_2 = Service portfolio nature  SO_3 = Turnover gained from services	Presence and accounting nature of the SBU Service  Number of advanced services offered  Percentage of the turnover gained from services
Maturity level of Installed Base Information Management Practices (MI)	MI_1 = Typologies of data collected from the Installed Base  MI_2 = Information system adopted to manage data collected from the Installed base	Breadth of data collected  Specialization and integration level of system implemented
Effect of Installed Base Information Management Practices (EI)	EI_1 = Benefits perceived from the IBIM practices	Number of benefits perceived from the Installed Base Information Management practices investigated

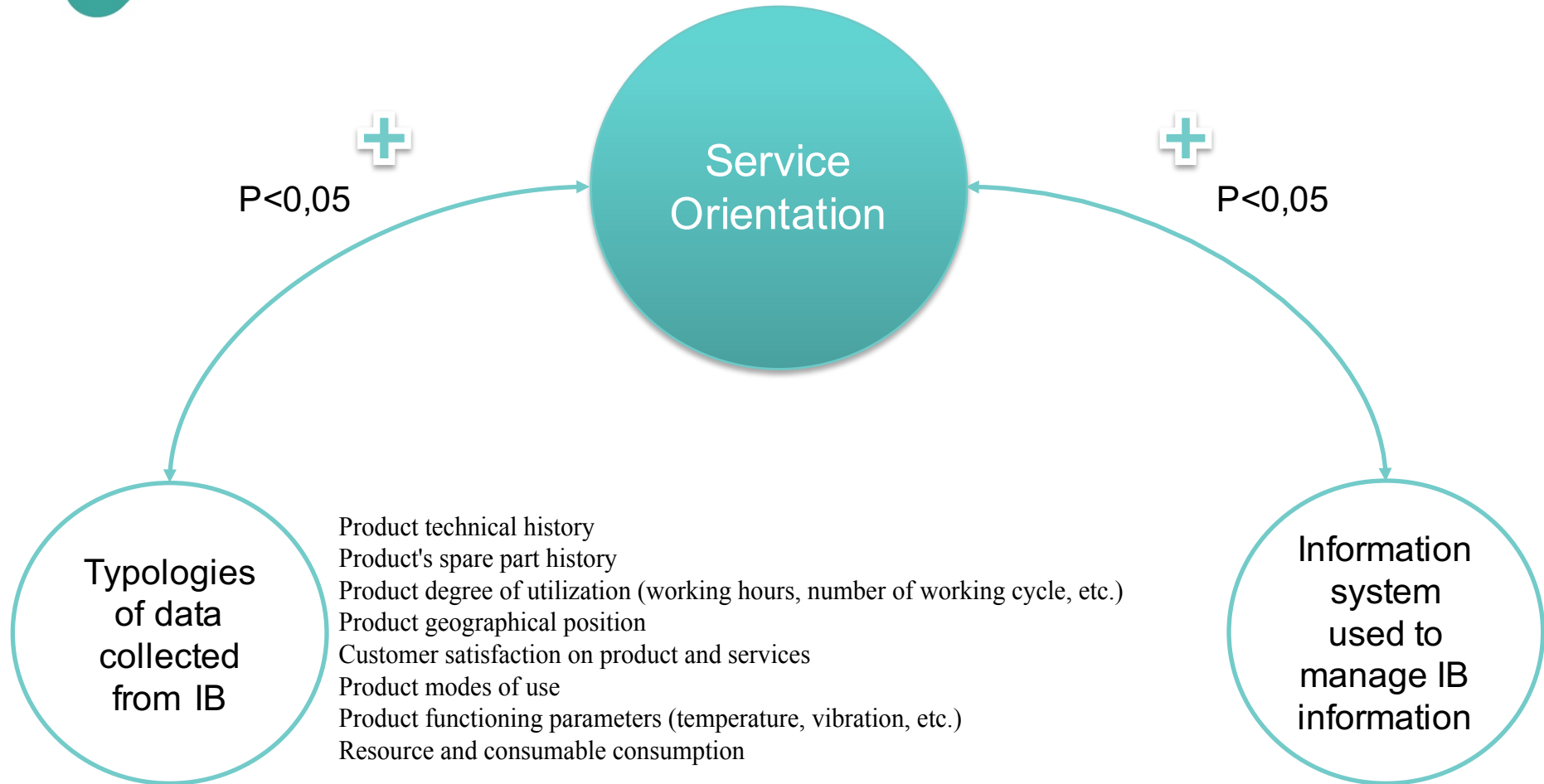


# Survey – Results

RQ1

RQ2

RQ3



*More pervasive field data collection*

*Wider adoption of IS such as ERP, CRM, PLM, PDM*



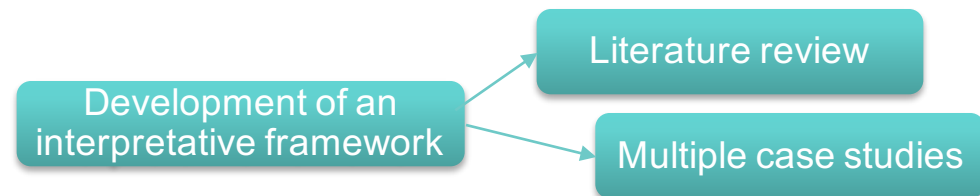
# Summary of findings related with RQ1

**RQ1:** *What are the installed base information management practices that can support a product-service integrated offering?*

- ▶ Definition of a set of practices related to Installed Base Information Management (IBIM) in a servitizing context
- ▶ Companies with a higher service orientation also develop more complex IBIM practices (see RQ3)

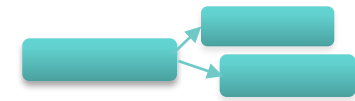
**However:**

- ▶ Large number of literature streams with a wide variety of topics and approaches
- ▶ Lack of framework and theories to describe and analyse servitization and installed base information issues (see RQ2)
- ▶ A new theoretical lens has been introduced in the study
  - A couple of paper analysed in the first phase mention the **Knowledge Management** as a key capabilities to overcome difficulties of *servitization*



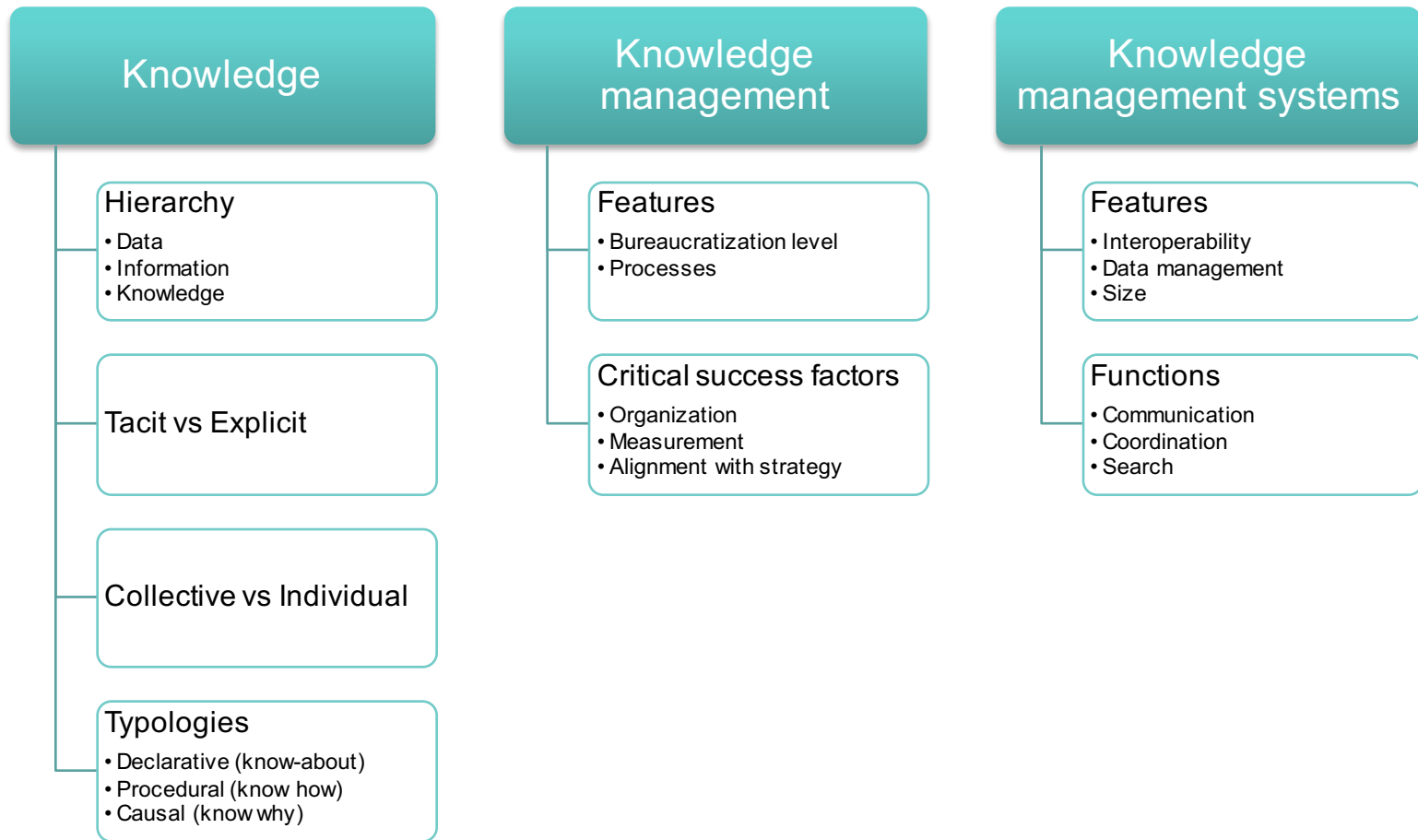


# Knowledge Management interpretative framework



- RQ1
- RQ2
- RQ3

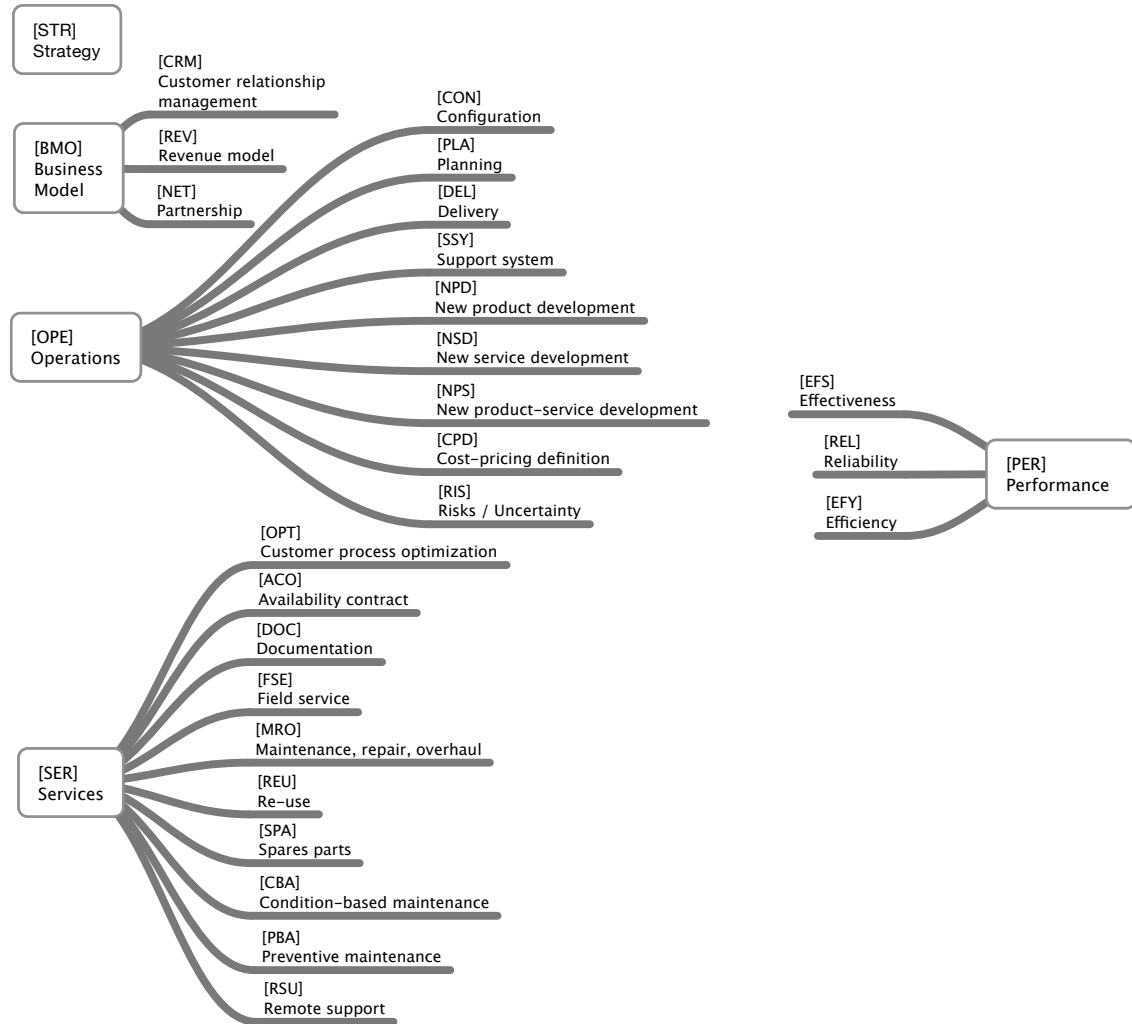
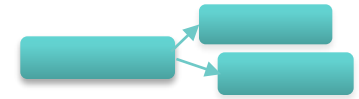
**RQ2:** *How can the role of installed base information in the servitization processes be analyzed through the knowledge management theoretical approach?*





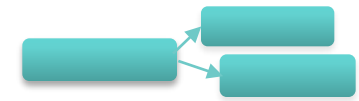
# Servitization practice framework

- RQ1
- RQ2
- RQ3





# The final interpretative framework



- RQ1
- RQ2
- RQ3

	Operations	Services	Business Model	Strategy	Performances
Knowledge					
Knowledge Management					
Knowledge Management System					

Each crossing aims to explain how the configuration of KM variables impacts on specific servitization practices (answer to RQ2)

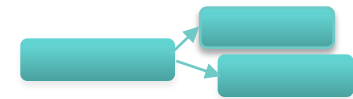


# Literature extension and analysis

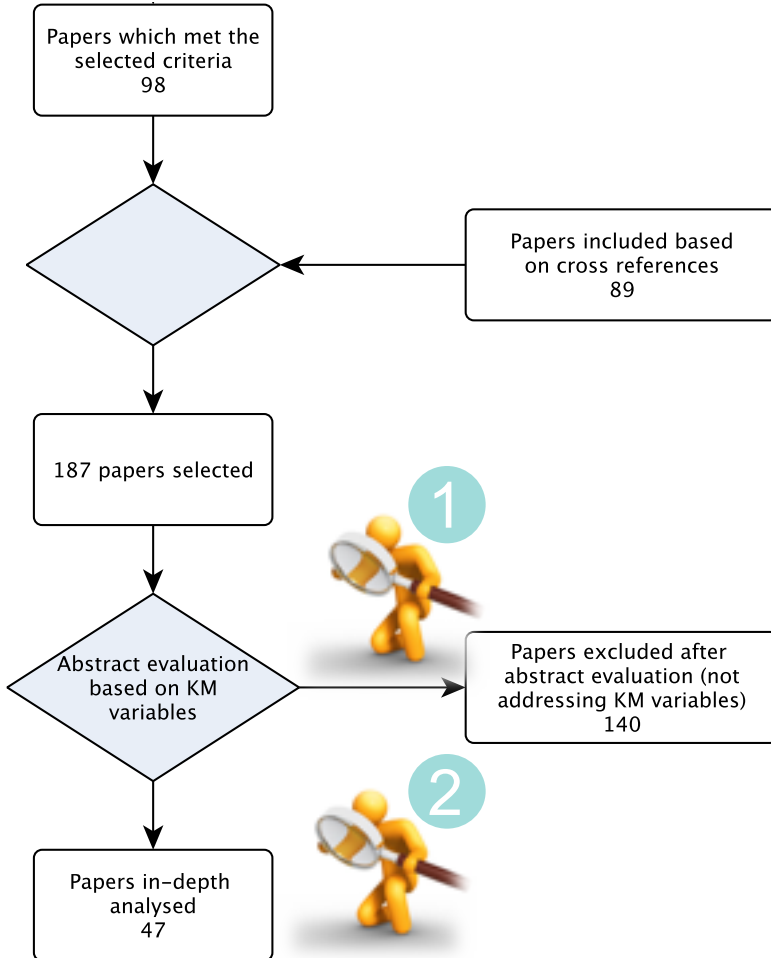
RQ1

RQ2

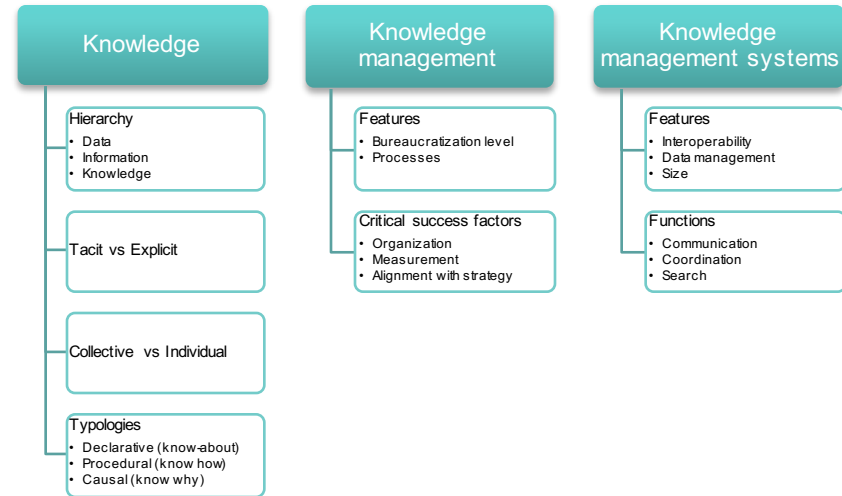
RQ3



**RQ3:** *How should a servitizing firm configure its knowledge management practices?*



1



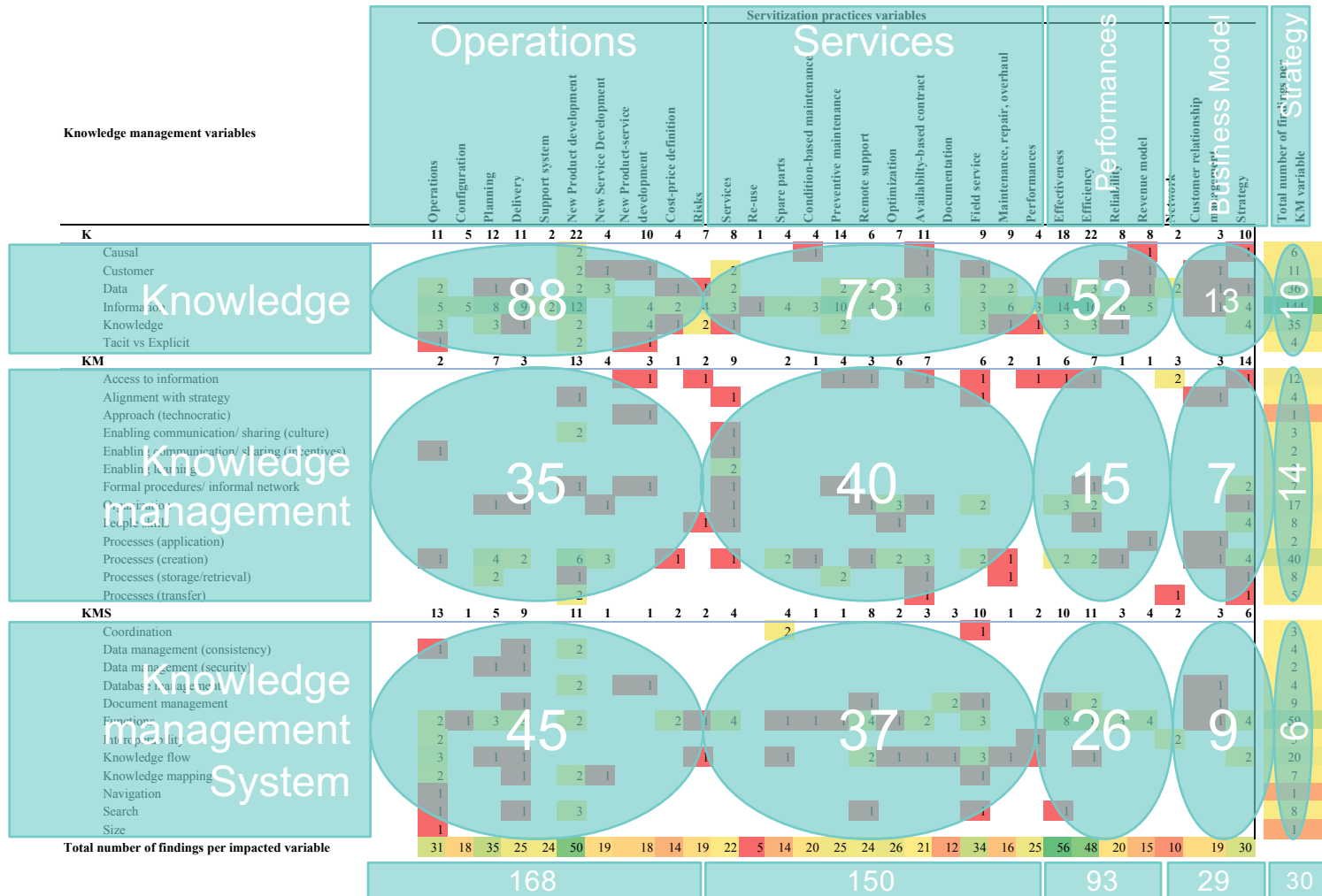
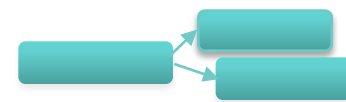
2

	Operations	Services	Business Model	Strategy	Performances
Knowledge					
Knowledge Management					
Knowledge Management System					



# Literature extension and analysis – Findings

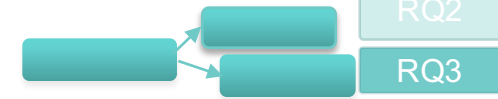
RQ1  
RQ2  
RQ3







# Literature extension and analysis – Results



## Knowledge

- ▶ Data should be gathered and aggregated from multiple source (technicians, customers, sensors)
- ▶ Explicitation effort is needed (incentives, taxonomies, ICT)

## Knowledge Management

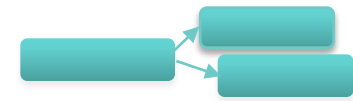
- ▶ Installed Base data collection strategy is needed (plus commitment, culture, interfunctional team)
- ▶ New skills are needed (data scientists/engineering)

## Knowledge Management System

- ▶ Remote monitoring technologies and ICTs are needed as well as common data model
- ▶ Ontologies should be implemented to formalize and explicit tacit knowledge



# The new theoretical framework



RQ1

RQ2

RQ3

	Operations	Services	Business Model	Strategy	Operations AND Services	Other joint impacts
<b>K</b>	<ul style="list-style-type: none"> <li>In-service</li> <li>Usage / performance</li> <li>Environmental / context</li> <li>Deterioration / maintenance</li> <li>Customer experience</li> <li>Explicit (ICTs, taxonomies)</li> </ul>	<ul style="list-style-type: none"> <li>Usage data</li> <li>Operators information</li> <li>Operation and maintenance information</li> <li>Customer information</li> <li>Use patterns</li> </ul>	<ul style="list-style-type: none"> <li>Usage data</li> <li>Operation information</li> </ul>	<ul style="list-style-type: none"> <li>Usage data</li> <li>Customer behaviour</li> <li>In-service knowledge</li> <li>Life-cycle knowledge</li> </ul>	<ul style="list-style-type: none"> <li>Usage data</li> <li>Process data</li> <li>Equipment data</li> <li>In-service information</li> <li>Performance information</li> <li>Fault information</li> <li>Update BOM</li> <li>Data model</li> <li>Customer feedback</li> </ul>	<ul style="list-style-type: none"> <li>Asset performance data</li> <li>Customer's business planning information</li> <li>Use patterns</li> <li>Operations information</li> <li>In-service information</li> </ul>
<b>KM</b>	<ul style="list-style-type: none"> <li>Personalization + Codification</li> <li>Technocratic approach</li> <li>Sharing culture</li> <li>Planning the use of data upfront (strategy)</li> <li>Incentives</li> <li>Business intelligence</li> <li>Qualitative description (interview)</li> <li>Statistical analysis &amp; data mining</li> <li>Language processing techniques</li> <li>Diagnosis algorithm</li> </ul>	<ul style="list-style-type: none"> <li>In-field access to knowledge base</li> <li>Training</li> <li>Motivational strategy</li> <li>Condition monitoring experts</li> <li>Management commitment</li> <li>Information triangulation</li> <li>Ontology</li> <li>Statistical analysis &amp; data mining</li> </ul>	<ul style="list-style-type: none"> <li>Data sharing</li> </ul>	<ul style="list-style-type: none"> <li>Personalization + codification</li> <li>Data smoothing</li> <li>Data mining</li> <li>Inter-functional coordination</li> <li>Condition monitoring experts</li> <li>Multi disciplinary skills</li> </ul>	<ul style="list-style-type: none"> <li>Statistical techniques</li> <li>Bayesian network</li> <li>Control centre</li> <li>Call centre</li> <li>Condition monitoring experts</li> <li>Product experts</li> <li>Data scientists</li> <li>In-field access to knowledge base</li> </ul>	<ul style="list-style-type: none"> <li>Data sharing (with customers and providers)</li> <li>Data processing and interpretation capabilities</li> <li>Bayesian network</li> <li>Asset information model</li> </ul>
<b>KMS</b>	<ul style="list-style-type: none"> <li>Data pre-processing</li> <li>Use pattern analysis</li> <li>Data access/security</li> <li>Context specific KM filters</li> <li>Ontology</li> <li>Common-data model</li> <li>IT platforms</li> <li>Remote monitoring and recording</li> </ul>	<ul style="list-style-type: none"> <li>GPS (Global positioning system)</li> <li>ICT</li> <li>Prognostics and Health Management (PHM)</li> </ul>	<ul style="list-style-type: none"> <li>Remote monitoring technologies</li> <li>Intelligent products</li> </ul>	<ul style="list-style-type: none"> <li>Transparency</li> <li>Real-time ICTs</li> </ul>	<ul style="list-style-type: none"> <li>Remote monitoring technologies</li> <li>Real-time ICTs</li> <li>Workflow</li> </ul>	<ul style="list-style-type: none"> <li>Web-based services</li> <li>ICTs</li> <li>Remote monitoring technologies</li> </ul>

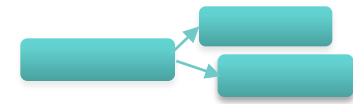


# Multiple case study – Methodology

RQ1

RQ2

RQ3



**RQ3:** *How should a servitizing firm configure its knowledge management practices?*

- ▶ 8 capital goods manufacturers operating in Italy have been purposely selected
- ▶ Personnel interviewed with a protocol: CEO, Service manager, CIO, technicians
- ▶ Constructs investigated:
  - **Service strategy** (using Gebauer et al. 2010 framework)
  - **K, KM, KMS**(using a subset of variables of the Knowledge Management interpretative framework)

itema



Mazak  
Your Partner for Innovation

PORTA SOLUTIONS.

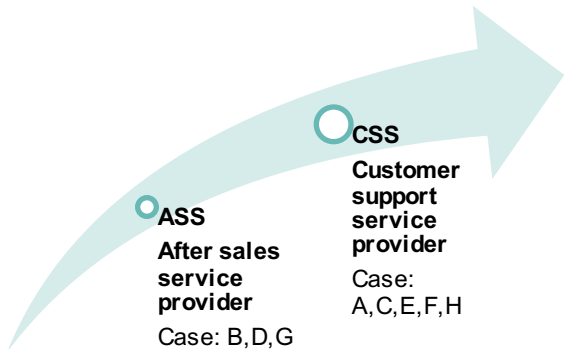
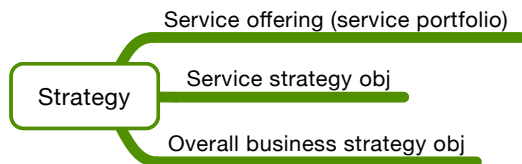


Balance Systems



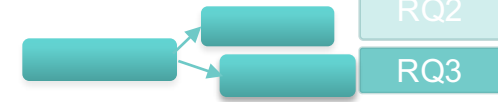
REA SERVICE

LEONARDO  
technological system integrator





# Multiple case study – Evidences



AREA	VARIABLES	BEST CASE	DESCRIPTION
K	Customer satisfaction	H	Customer feedback are collected after each technical intervention
K	Service calls	H	Information collected during the first contact with the customer are stored in the information system, even if the problem is solved during the same call
K	Skill metrics	C	Technicians' skills are explicated in specific maps that are periodically updated
KM	Technical report quality evaluation	C	Quality of data collected by field service technicians in technical reports are evaluated after each intervention
KM	Data integration	C	Every data collected during the field service process are stored and managed within the information system
KM	Incentives	F	Collection of commercial data and information by service technicians which may lead to sales opportunity are fostered by economic incentives
KM	Performance monitoring	F	Data collected during the remote diagnosis of the problem are used to monitor its performances thanks to a KPI's dashboard
KMS	Search in report archives	H	Data and information collected within field service intervention reports are codified and therefore can be easily retrieved
KMS	Search keywords	H	The majority of data collected during the field service process are searchable using keywords
KMS	Offsite access	H	Field technicians can access to all historical information related to previous intervention as well as product documentation when in field



# Multiple case study – Results

- ▶ Responses have been coded
- ▶ Pattern matching and cross-case analysis

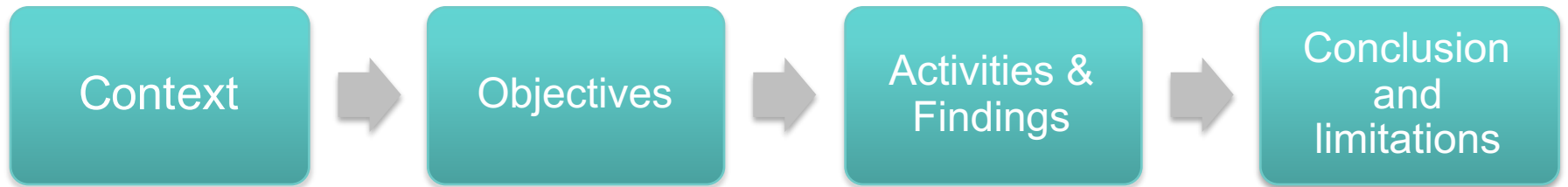
	Variables	Cases							
		A	B	C	D	E	F	G	H
<b>Control</b>	Strategy	CSS	ASS	CSS	ASS	CSS	CSS	ASS	CSS
	Employees	213	31	830	81	30	231	67	103
<b>Knowledge</b>	Customer satisfaction	L	L	L	L	M	L	L	M
	Service calls	H	M	L	L	L	M	L	H
	Skill metrics	L	L	H	L	L	L	L	H
<b>Knowledge Management</b>	Technical report quality evaluation	L	L	H	M	L	M	M	M
	Data integration	M	L	H	M	L	M	L	M
	Incentives	L	L	L	L	L	M	L	L
	Performance monitoring	L	M	M	L	L	H	M	L
<b>Knowledge Management System</b>	Search in report archive	H	M	M	L	L	L	L	H
	Search keywords	H	M	H	L	L	L	L	H
	Offsite access	L	L	L	L	M	L	L	H
	<b>% of High values</b>	30%	0%	40%	0%	0%	10%	0%	50%
	<b>% of Medium values</b>	10%	40%	20%	20%	20%	40%	20%	30%
	<b>% of Low values</b>	60%	60%	40%	80%	80%	50%	80%	20%

# Multiple case study – Results

- ▶ Firms which are implementing a more advanced strategy such as the Customer Service Strategy, tend to be more mature in terms of Knowledge Management practices
- ▶ One of the case that pursues a Customer Service Strategy (E) has mostly low and medium level of maturity across the investigated variables
  - In the relationship among the service strategy and the maturity of the Knowledge Management practices the size of the firms may play a mediatory role



# AGENDA





# Contributions

## Theoretical

- Identification of a positive relationship between service orientation and IBIM maturity
- Definition of a theoretical framework to formalize the role of KM practices in a servitizing context
- Classification of KM practices in a servitized context
- Definition of the impacts of KM practices on servitization practices

## Practical

- Assessment of criticalities in the management of installed base information, improvement proposal based on declared service strategy
- Identification of best practices that can be replicated in similar setting
- Creation of a prescriptive framework that can guide servitizing firms in the configuration of KM practices according to their strategy





# Research outcomes

Object	Conference / Journal	Place / date	Relevance	Title of presented paper	Co-authors
Conference participation (presenting author)	XXVII Summer School Francesco Turco "Breaking down the barriers between research and industry"	Venice, 12-14 September 2012	National	The Role of Installed Base Information in Product-Service System: an empirical investigation	Saccani N., Perona M.
Conference participation (presenting author)	APMS 2012 International Conference on "Competitive Manufacturing for Innovative Products and Services"	Rhodos, 24-26 September 2012	International	The Value and Management of Installed Base Information in Product-Service System	Saccani N., Borgman J.
Conference participation (presenting author)	EurOMA Conference: "Operation Managements at the Heart of the Recovery"	Dublin, 7-12 June 2013	International	The Role of Installed Base Information in the Implementation of Service-led Business Models: an Empirical Investigation and a Literature Review	Saccani N., Aggogeri F.
Conference participation (presenting author)	XXIV International RESER Conference	Helsinki, 11-12 September 2014	International	Development of a Knowledge Management framework to support installed base information management practices in a servitized context	Saccani N.
Conference participation	Spring Servitization Conference	Aston, 18-19 May 2015	International	The Role of Installed Base Information in Servitization: a Knowledge Management View	Saccani N., Perona M.
Journal ISI	Production Planning and Control	In press	International	Internal and external alignment in the servitization journey – Overcoming the challenges	Saccani N.



## Limitations and future steps

- ▶ The Knowledge Management interpretative framework has been developed through the analysis of seminal paper
- ▶ Survey and case company are all from Italy and operate in the same main sector (limited generalizability)
  - **Future step could be the development of an explanatory survey**
- ▶ From case study results emerges an almost unanimous low maturity of the KM practices when compared to literature results (quality of the cases?)
- ▶ It's still unclear how to evaluate the maturity level of KM practices
- ▶ An open question is still how to measure the magnitude of the economic impact on the manufacturer of knowledge management practices performed in the field of service-oriented offering
  - **Future step could be the application of a set of tools identified within action research project**



# CONTACT



## Andrea Alghisi

Department of Mechanical and Industrial Engineering  
University of Brescia – Italy

E-mail: [andrea.alghisi@unibs.it](mailto:andrea.alghisi@unibs.it)

He is a postdoc at the University of Brescia (Italy). He graduated in July 2011 in Industrial Engineering and holds a PhD in Design and Management of Logistics and Production Systems. He is a member of the RISE Lab (Research and Innovation for Smart Enterprises) ([www.rise.it](http://www.rise.it)). He also participates in the ASAP Service Management Forum ([www.asapsmf.org](http://www.asapsmf.org)), where he carries out scientific dissemination activities (e.g. workshop) and company transfer projects. He conducts research in the servitization field, especially in the machinery sector.

