Product Service Systems value chain configuration – a simulation based approach

by

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Introduction
Increasing customers’ individual requirements

- Increasing customer individual demands in both B2C and B2B contexts
  → Companies to seek more customer-centered business strategies
  → New forms of supplier–customer relationships
Introduction
Decoupling environmental degradation from economic growth
Introduction
Transition towards Product Service Systems (PSS)

• Business is shifting from offers based on traditional physical products to Product-Service Systems (PSS)
• Transition towards PSS entails risks relating to the new forms of suppliers-customer relationship, business model, etc.
→ Decision-makers require feedback on the viability of PSS solutions in order to make more informed decisions (Cavalieri and Pezzotta, 2012)

However...

• Tools and methods to support the organizational transition, at the operational level are scarce (Meier et al., 2010; Boucher, 2012; Beuren et al., 2013)

→ Aim of this research: enable well informed decisions regarding PSS value chain configuration, thus mitigating the uncertainty underpinning PSS implementation
→ Approach: A framework relying on a combination of a methodological approach with modelling and simulation
Outline

• Stakeholders integration and life cycle perspective in PSS design
• PSS configuration and scenarios definition
• Methodological framework to support PSS design
• Simulation model for PSS assessment
• Case study in the sludge treatment sector
• Conclusions and research perspectives
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Product-Service Systems design (1/2)
Life cycle perspective and stakeholders integration

- Industrial Product-Service Systems emerge as a promising business model for manufacturing companies
- A PSS “… is characterized by the integrated and mutually determined planning, development, provision and use of product and service shares…” (Meier et al., 2010)
  → Joint development of products and services

- Purchasing cost accounts for no more than 50% of the whole PSS life-cycle costs (Meier et al., 2010, Mannweiler et al., 2010)
  → A life cycle perspective

- Need for operational solutions (Davies, 2004; Aurich et al., 2010; Baines et al., 2009; Mannweiler et al., 2010; Beuren et al., 2013)
- Need to develop tools that consider service operation (i.e. service production) (Meier et al., 2010, Mannweiler et al., 2010)
  → Operational tools to fill the gap left by the focus on conceptual level

- PSSs draw upon a lot of internal and external resources (Meier et al., 2010; Kimita and Shimomura, 2014, etc.)
  → A PSS network perspective
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Challenge for the PSS assessment in *priori*…

- Heterogenous data, e.g. activities, services, products, etc.
- Various stakeholders, e.g. product provider, service provider, etc.

→ Scenarios allows the recognition of potential threats *prior to implementation* of the PSS solution

- Scenario: combination of a given PSS configuration, activities and PSS actors having specific roles with the value chain
- Need to define the different *performers of value chain activities*

→ Scenarios are an appropriate tool for conceptualizing the potential *value-chain configurations*
→ A *multi-actor perspective* is required to reflect actors' standpoints
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Aim: support the rapid development of **Decision Support Systems** (DSS) for **PSS value-chain configuration**

Focus: Small and Medium sized Enterprises (SMEs), in particular, a PSS value chain that is configured around a focal company leading the PSS
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Methodological framework to support PSS design (2/2)

Simulation model for PSS assessment

- **Inform decision-makers** of the potential organizational and economic spinoffs
- **Mitigating PSS implementation related risks**

→ Deterministic continuous simulation model

### Simulation Algorithm

1. **Calculate number of required contracts according to the market volume during the period**
2. **If new contracts are needed, assign one or more contract types to the period**
3. **Check the inventory of product including returns, and update the in-progress production**
4. **Update the list of ongoing contracts of the current period**
5. **Update the list of available contracts at the end of the period**
6. **Update performance indicators**

### Data Inputs
- Market demand
- Production data
- Logistics data
- Accounting data
...

### Data Outputs
- Costs
- Benefits
- Profit
- Cash flow
...

### Programming Language
- Visual Basic Language
- Microsoft Office Excel
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Case study in the sludge treatment sector (1/9)

Context of the case study

→ get rid of the sludge!

Actors:
- Manufacturers producing sludge
- End-of-Life treatment company

→ make money out of the sludge and save natural resources!

Actors:
- Manufacturers producing sludge (potential customers of the envisioned PSS solution)
- Equipment provider (i.e. briquette-making equipment)
- Smelters using electric arc furnaces for melting steel scrap and other metals (potential customers for the produced briquettes)
Case study in the sludge treatment sector (2/9)
Organizational scenarios identification

- Semi-structured interviews with the PSS actors
- 18 organisational scenarios
- Selection according to i) compliance to regulations, ii) added value for the value-chain actors, including final customer.
- S1: equipment provider sells the equipment to the manufacturers (who compact and sell briquettes to smelters)
- S2: equipment provider rents the equipment to the manufacturers (who compact and sell briquettes to smelters)
- S3 equipment provider sells the equipment to an intermediary (who compacts and sells briquettes to smelters)
- S4: equipment provider offers the compacting service (mobile equipment)
Case study in the sludge treatment sector (3/9)
Performance evaluation model building

- Cost (services, production, logistics, etc)
- Revenues (services, equipment sales, briquettes sales, cutting fluid economies, waste treatment economies, etc.)
- And… Profit
  → Quite traditional indicators…
  However…
  → This all the partners needed… so far
The collection process is based on **questionnaires** and on **face-to-face meetings** → challenging because of the **multi-actor perspective** and the **heterogeneity of the data**
Case study in the sludge treatment sector (5/9)

Experimentation plan for S1-S3

<table>
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<th>Scenario</th>
<th>Waste treatment cost (€/tonne)</th>
<th>Scrap cost (€/tonne)</th>
<th>Market (tonne of sludge)</th>
<th>Contract duration (year)</th>
<th>Customer profil</th>
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LA: Little Autonomy; FA: Full Autonomy; SH: Slightly Hard; VH: very Hard; SD: Standard
Case study in the sludge treatment sector (6/9)

Experimentation plan for S2-S4

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Case study in the sludge treatment sector (7/9)

Regression tree for Equipment Provider profit

Best configuration:
Scenario 2
Very Hard Sludge

Specific PSS case study

- Context analysis
- Usage analysis and scenarios prioritization
- Performance evaluation model building
- Implementation and data collection
- Scenarios performance evaluation

Scenario 2 performance:
€484,994

Scenario 3 performance:
€753,164
Case study in the sludge treatment sector (8/9)

Regression tree for manufacturers profit

Best configuration: Market Volume > 140
Scenario 3

Specific PSS case study

Context analysis
Usage analysis and scenarios prioritization
Performance evaluation model building
Implementation and data collection
Scenarios performance evaluation

261 337 €
823 049 €
295 301 €
There exist several drivers for the actors’ performances, such as the market volume, and roles assigned to actors within the PSS value chain.

Scenarios are the most important drivers of performance. Therefore, the configuration of the value chain, which defines the roles assigned to each actor, has a notable leverage effect.

Scenario 4 is unprofitable for both equipment provider and manufacturers.
Scenario 2 is the most interesting one for the equipment provider, in terms of profitability, but it is unprofitable for the manufacturers.
Scenarios 1 and 3 are profitable for both equipment provider and manufacturers.

→ Trade-offs should be made to cope with both equipment provider and manufacturers’ requirements.
→ A reasonable foundation for further investigation regarding the impact of other parameters, e.g. geographical dispersion of the actors, demand thresholds, etc.
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Summary and research avenues

- The framework provides a **methodological guidance**
- Assessment of PSS value chains configurations using **Simulation-based DSS**
- The case study provides evidence on the framework **applicability** and added value

**However, it leaves a lot to be desired...**
- Assessment according to the three PSS feasibility pillars; **business viability**, **customer satisfaction** and (**environmental soundness**) (Mont, 2002; Yoon et al., 2012)
- Evaluate whether the PSS solution meets **customers' requirements** (Geng et al., 2011; Mert et al., 2014; Shimomura et al., 2015)
- **Quantification of uncertainty** to strengthen the decision-aid provided to PSS actors
- Operational level involving **production and delivery management** (the territorial perspective)

**And...**
- Transferring concepts such as **commonality** and product **modularity** to the PSS
  - leverage PSS potential for companies, customer and environment
References

Thank you!