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# An approach to select suppliers for sustainable collaborative networks

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# Introduction

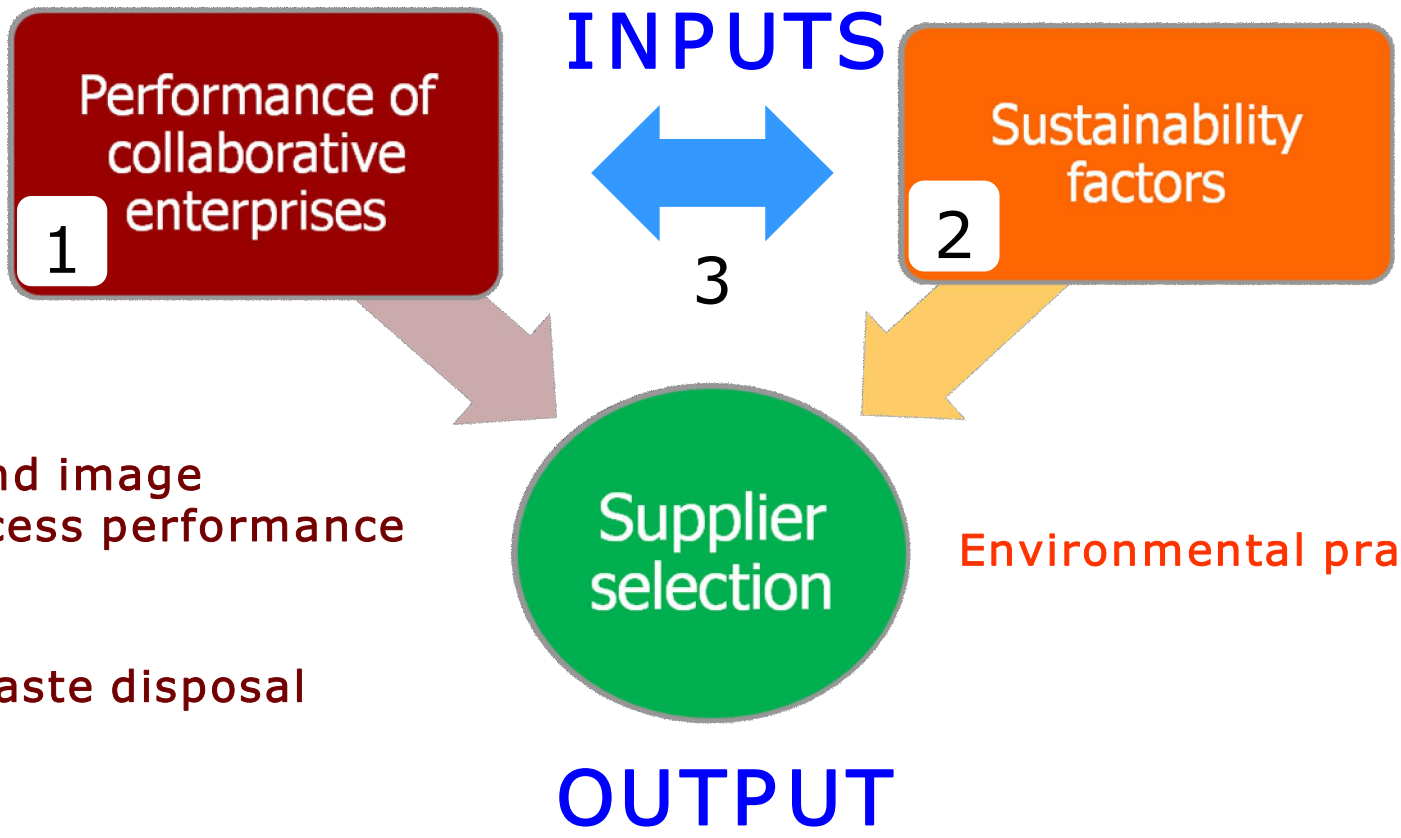
- Supplier selection **crucial process** for competitiveness.
- Even more **complex if this decision involves different partners** that are already collaborating and desire to choose a partner for **enhancing the sustainability** of their collaborative supply chain/ network.

- Studies point out the importance of Performance Measurement (PM) for the whole supply chain. PM framework for **managing the collaborative association** & focus efforts on their common strategy.
  - Use ***structured PM framework***: overview of performance status.
  - Balanced ScoreCard (BSC): extended for interorganizational contexts
- Pressures for improving the sustainability.
  - Sustainability factors: ***environmental, social, and economic factors.***

- **How can we evaluate suppliers in these contexts?**

# Introduction

- **How can we evaluate suppliers in this context?**



# Introduction

*With this approach, enterprises can select suppliers aligned to their common strategy and improving the sustainability of the whole enterprise association.*

# Background

## Most Decision Problems are Multi-criteria

- Maximize profits
- Satisfy customer demands
- Maximize employee satisfaction
- Satisfy stakeholders
- Minimize costs of production
- Satisfy government regulations
- Minimize taxes
- …

# Background

- **Multi-criteria methods applied for supplier selection:**
  - **AHP**
  - **ANP**
  - **DEA**
  - **VPA**
  - **MAUT**
  - **SMART**
  - **Goal Programming**
  - **TOPSIS**
  - **ELECTRE**
  - **PROMETHEE**
  - **…**

# Background

- **Selecting one method depends on characteristics:**
  - **Decision maker (individual or group),**
  - **Nature of the alternatives (discrete or continuous),**
  - **Type of criteria (quantitative, qualitative or mixed),**
  - **Data aggregation,**
  - **Relationships among criteria (independence or interdependence),**
  - **etc.**

# Background

- **Multi-criteria methods:**
  - **AHP**
  - **ANP**
  - **DEA**
  - **VPA**
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  - **SMART**
  - **Goal Programming**
  - **TOPSIS**
  - **ELECTRE**
  - **PROMETHEE**
  - **…**

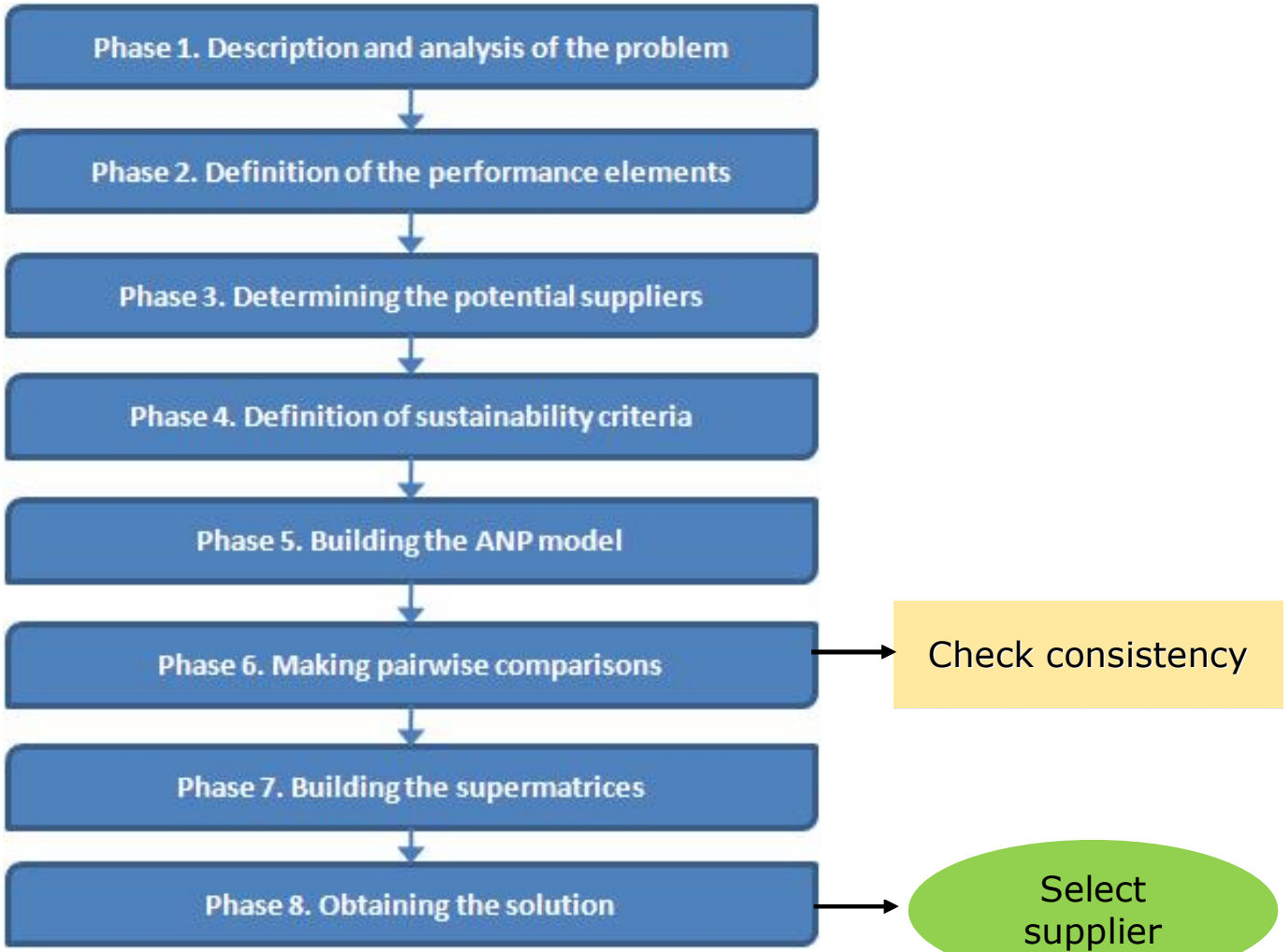
ANALYTIC NETWORK PROCESS (ANP)
- Group Decision
- Quantitative and Qualitative criteria
- Interrelationships

# Background

- The ANP has been previously used for supplier selection under a wide variety of applications within interorganizational contexts. Some of them…
  - Select suppliers depending on different levels of cooperation
  - Select members for an agile virtual enterprise
  - Select suppliers within specific industries such as pharmaceutical industry
  - …
- Few ANP models consider sustainability factors
- **Research gap:** ***integrate both sustainability factors and overall interorganizational performance to select suppliers***
- Both inputs are *interrelated*.

# The approach for supplier selection

- **Phases:**



# The approach for supplier selection

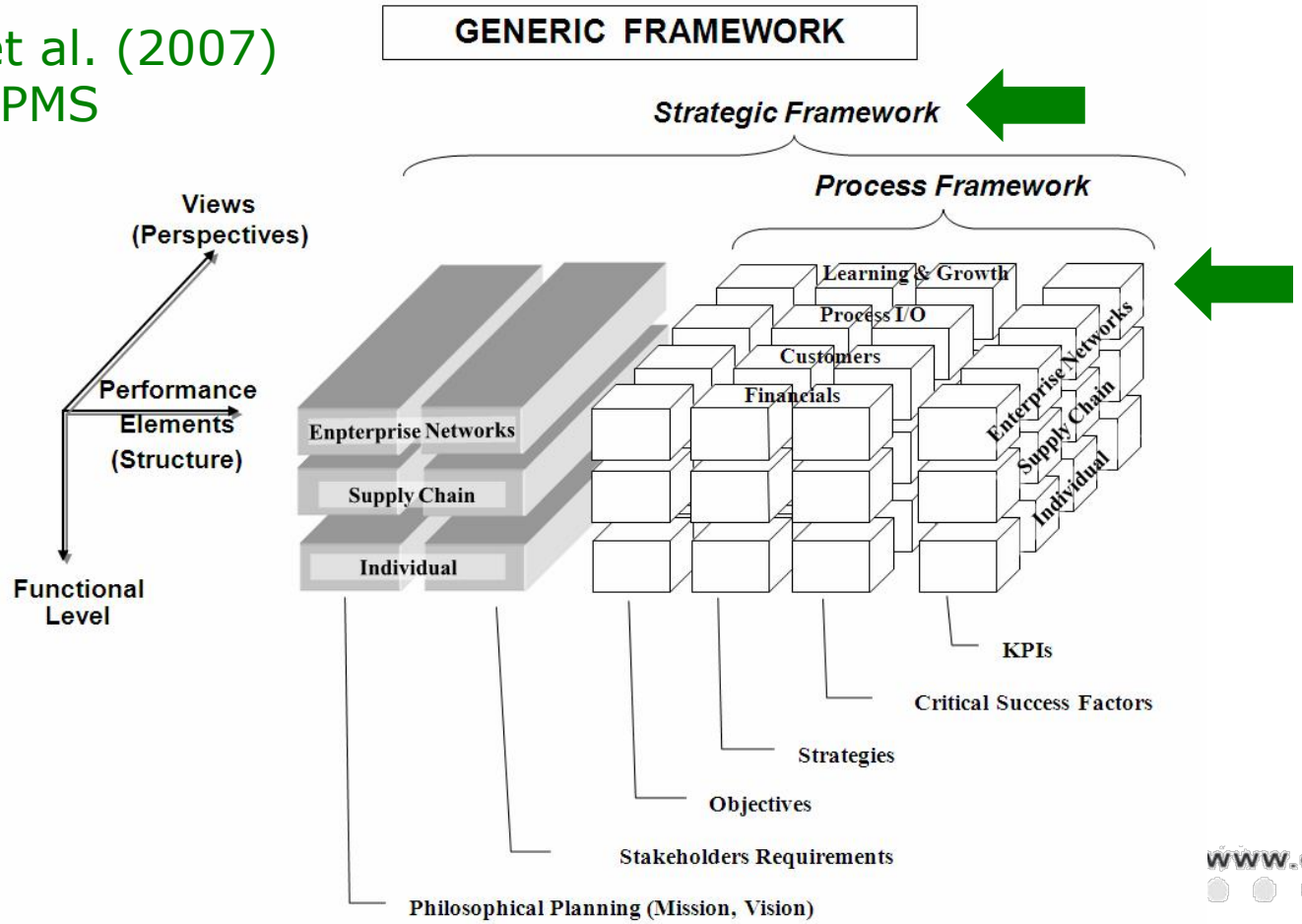
## Phase 1. Description and analysis of the problem

- Enterprises
- Products
- **Sector**
- **Customers**
- **Collaboration agreements**
- **Group of experts**
- **Supplier selection need**
- **Supplier characteristics**

# The approach for supplier selection

## Phase 2. Definition of performance elements

Alfaro et al. (2007)
PMS



# The approach for supplier selection

## Phase 3. Determine potential suppliers

- Supplier 1
- Supplier 2
- Supplier 3
- ….

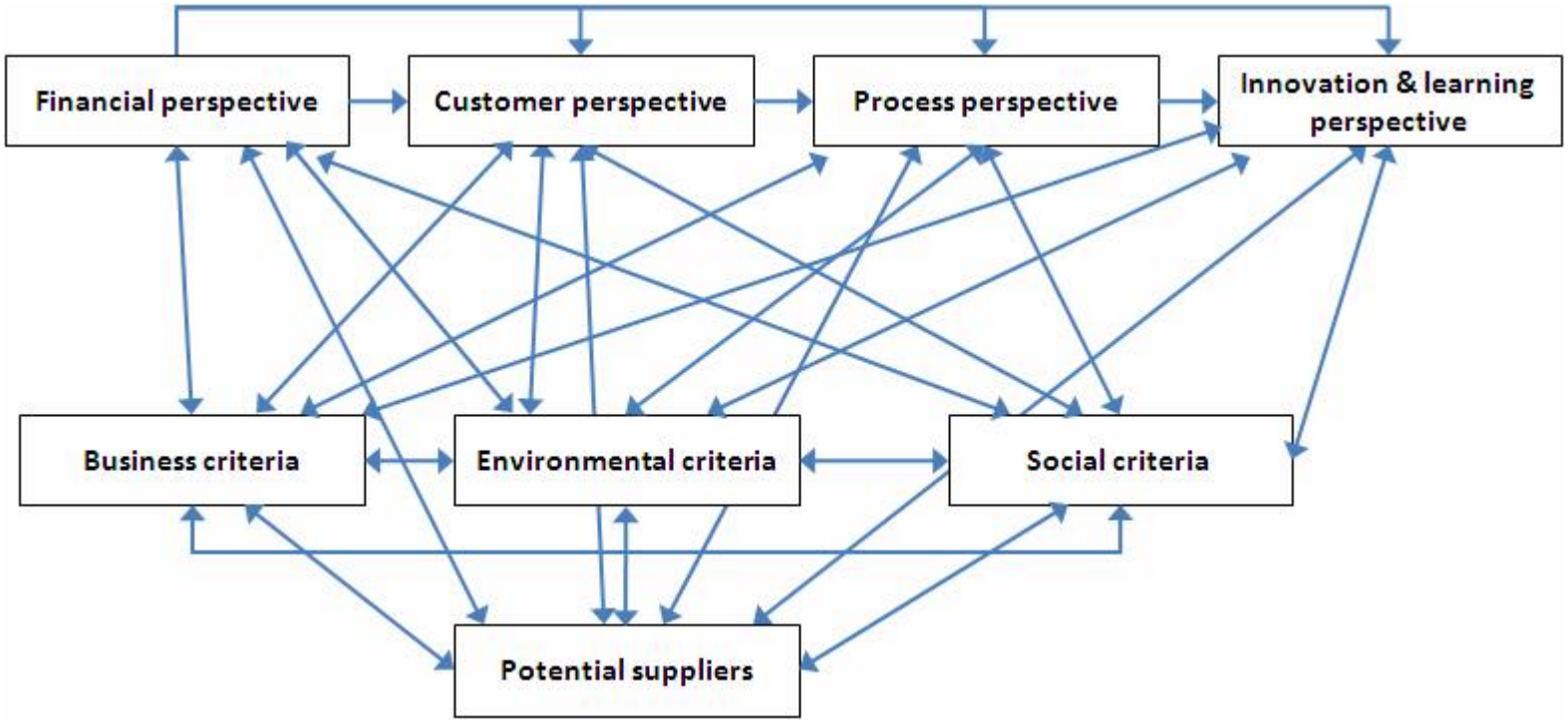
# The approach for supplier selection

## Phase 4. Definition of sustainability criteria

- Increasing growth in sustainability awareness.
- Review of conceptual frameworks of collaboration and sustainability within interorganizational contexts.
- Validation by the group of experts.

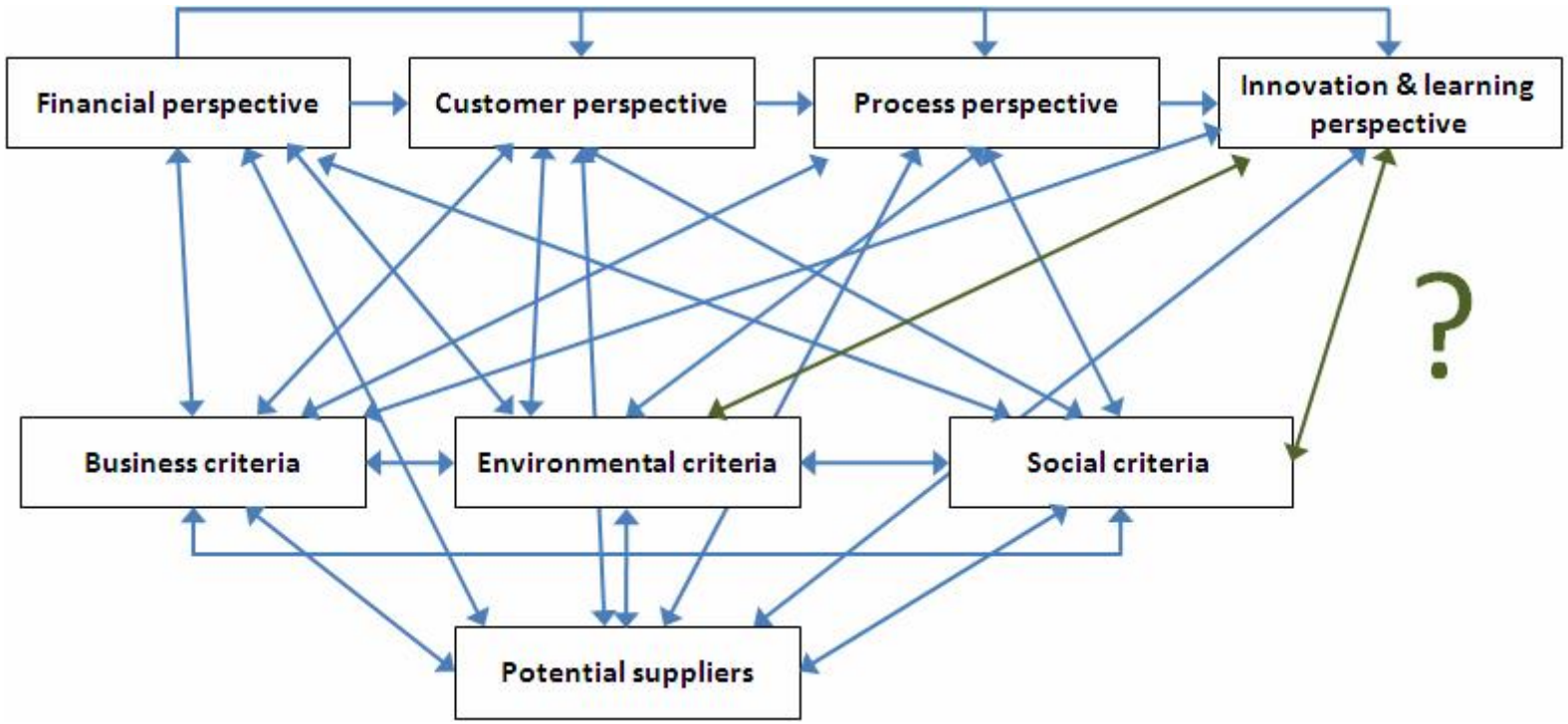
# The approach for supplier selection

## Phase 5. Building the ANP model



# The approach for supplier selection

## Phase 5. Building the ANP model



# The approach for supplier selection

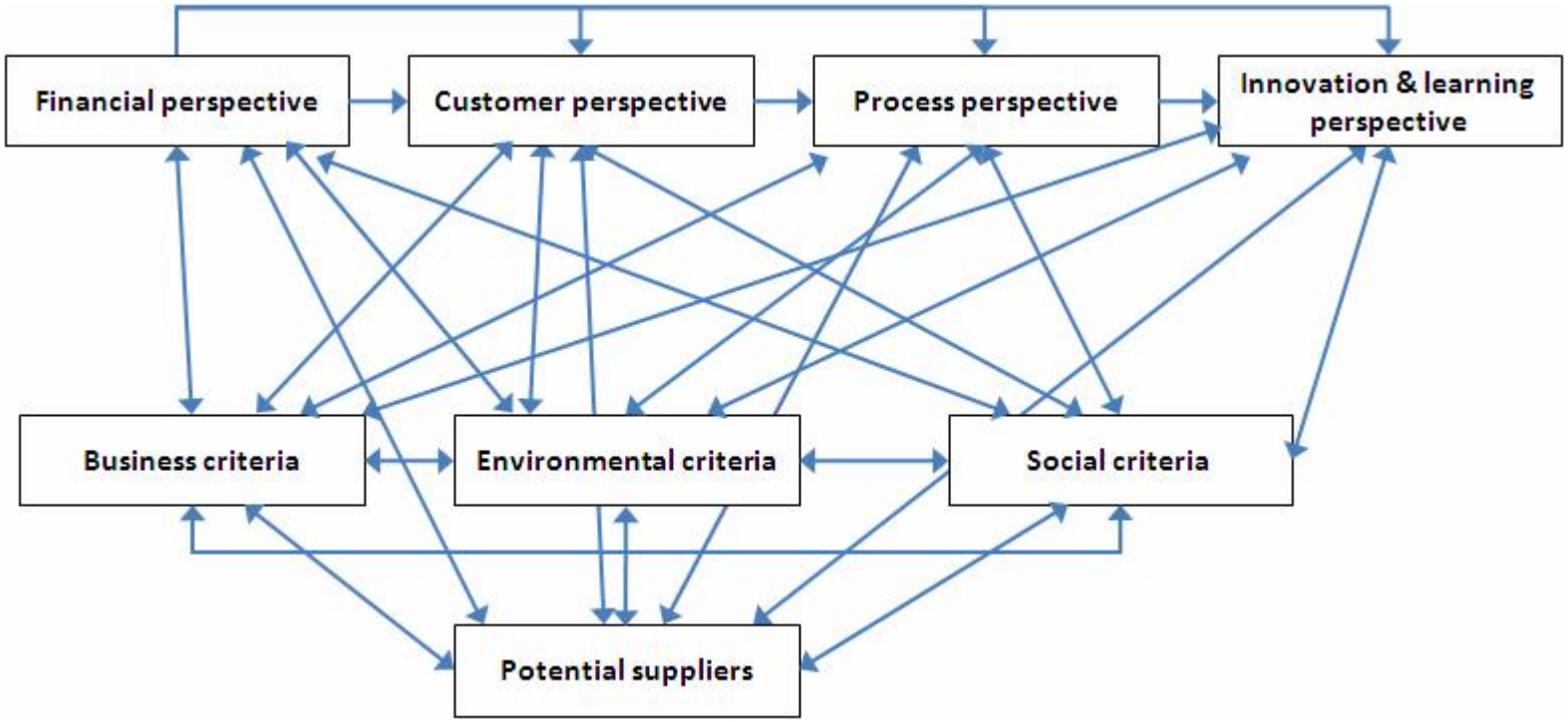
## Phase 5. Building the ANP model

Matrix of Influences among Elements

| | | FP | | CP | | ... | | BC | | EC | | ... | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P1 | ... | CP1 | ... | ... | ... | C1 | | EC1 | ... | ... | ... |
| FP | FP1 | 0 | | | | | | | | | | | |
| | ... | X | | | | | | | | | | | |
| CP | OP1 | X | | | | | | | | | | | |
| | ... | 0 | | | | | | | | | | | |
| ... | ... | | | | | | | | | | | | |
| | ... | | | | | | | | | | | | |
| BC | BC1 | | | | | | | | | | | | |
| | ... | | | | | | | | | | | | |
| EC | EC1 | | | | | | | | | | | | |
| | ... | | | | | | | | | | | | |
| ... | ... | | | | | | | | | | | | |
| | ... | | | | | | | | | | | | |

# The approach for supplier selection

## Phase 5. Building the ANP model



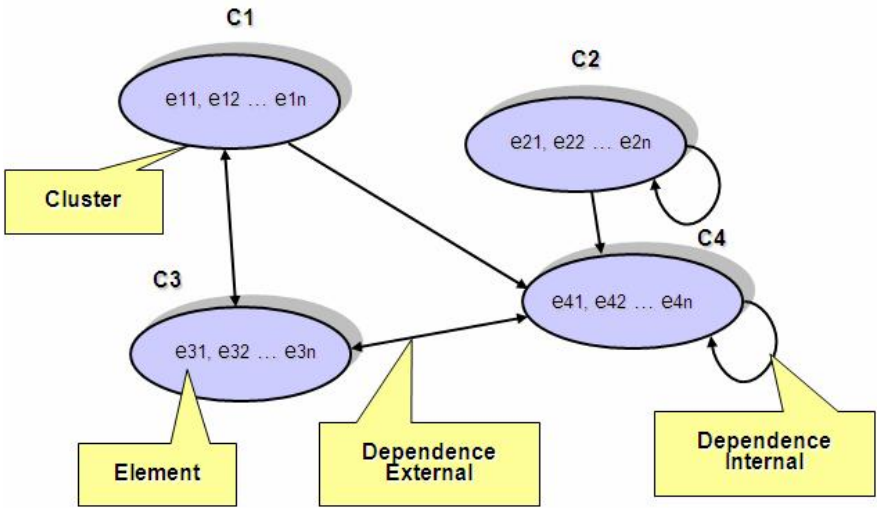
# The approach for supplier selection

## Phase 6. Making pairwise comparisons

Pairwise comparison matrix among elements

Calculate priority vectors & consistency

| | eij | eik |
|---|---|---|
| eij | cij,ij | cij,ik |
| eik | cik,ij | cik,ik |




| Intensity | Description |
|---|---|
| 1 | Same influence |
| 3 | Moderate |
| 5 | Strong |
| 7 | Very strong |
| 9 | Extreme |
| 2 ,4 ,6, 8 | Intermediate values |

Fundamental scale Saaty (1980)

# The approach for supplier selection

## Phase 7. Building the supermatrices

*Unweighted supermatrix*

Clusters

Elements

| | | FP | | CP | ... | BC | | EC | ... | S | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ... | P1 | CP1 | ... | ... | C1 | EC1 | ... | ... | S1 ... |
| FP | FP1 ... | $W_{FP,FP}$ | | $W_{FP,CP}$ | ... | $W_{FP,BC}$ | | $W_{FP,EC}$ | ... | ... | |
| CP | CP1 ... | $W_{CP,FP}$ | | $W_{CP,CP}$ | ... | $W_{CP,BC}$ | | $W_{CP,EC}$ | ... | ... | |
| ... | ... ... | ... | | ... | ... | ... | | ... | ... | ... | |
| BC | BC1 ... | $W_{BC,FP}$ | | $W_{BC,CP}$ | ... | $W_{BC,BC}$ | | $W_{BC,EC}$ | ... | ... | |
| EC | EC1 ... | $W_{EC,FP}$ | | $W_{EC,CP}$ | ... | $W_{EC,BC}$ | | $W_{EC,EC}$ | ... | ... | |
| ... | ... | ... | | ... | ... | ... | | ... | ... | ... | |
| S | S1 ... | $W_{S,FP}$ | | $W_{S,CP}$ | | $W_{S,BC}$ | | $W_{S,EC}$ | | $W_{S,S}$ | |

# The approach for supplier selection

## Phase 8. Obtain the solution

*Limit matrix*

Ranking of KPIs

| Rank | | L.P | N.L.P |
|---|---|---|---|
| 1 | FP1 | 0,0950 | |
| 2 | CP1 | 0,0680 | |
| 3 | IL1 | 0,0620 | |
| 4 | … | | |
| 5 | …. | | |

Ranking of Sustainability Criteria

| Rank | | L.P | N.L.P |
|---|---|---|---|
| 1 | BC1 | 0,1536 | |
| 2 | EC1 | 0,1099 | |
| 3 | SC1 | 0,1056 | |
| 4 | … | | |
| 5 | …. | | |

Ranking of Suppliers

| Rank | | L.P | N.L.P |
|---|---|---|---|
| 1 | S1 | 0,0350 | 0,4436 |
| 2 | S2 | 0,0272 | 0,3447 |
| 3 | S3 | 0,0167 | 0,2117 |
| 4 | … | … | … |
| 5 | …. | … | … |

# Case study

## Phase 1. Description and analysis of the problem

- Research Project: *"Design and Implementation of Performance Measurement Systems within Collaborative Contexts for aiding the Decision-making Process".*

- Collaborative enterprise network (raw material suppliers, badge supplier and injection moulding manufacturers) belonging to the automotive industry in Spain.
- Selecting the best supplier of one high-volume metallic sub-assembly.
- Group of experts: Managing directors of purchasing and R&D departments were in charge of the assessment of the suppliers and the authors of this paper acted as consultants.

# Case study

## Phase 2. Definition of performance elements

- 1. Mission and vision
- 2. Performance objectives: BSC
- 3. Performance indicators : BSC
  - Financial perspective: sales volume and profitability
  - Customer perspective: new product development, customer loyalty and market share.
  - Process perspective: on-time delivery orders, total cycle time, non-conforming parts delivered to customer and waste disposal.
  - Innovation & Learning perspective: …
- *4. Check consistency among them.*

# Case study

## Phase 3. Determine potential suppliers

- The three suppliers currently delivering the sub-assembly have the capability and know-how to manufacture the component.
  - Supplier 1. Spanish supplier located in Barcelona
  - Supplier 2. Foreign supplier (Swiss supplier)
  - Supplier 3. Spanish supplier located in Bilbao (North of Spain)

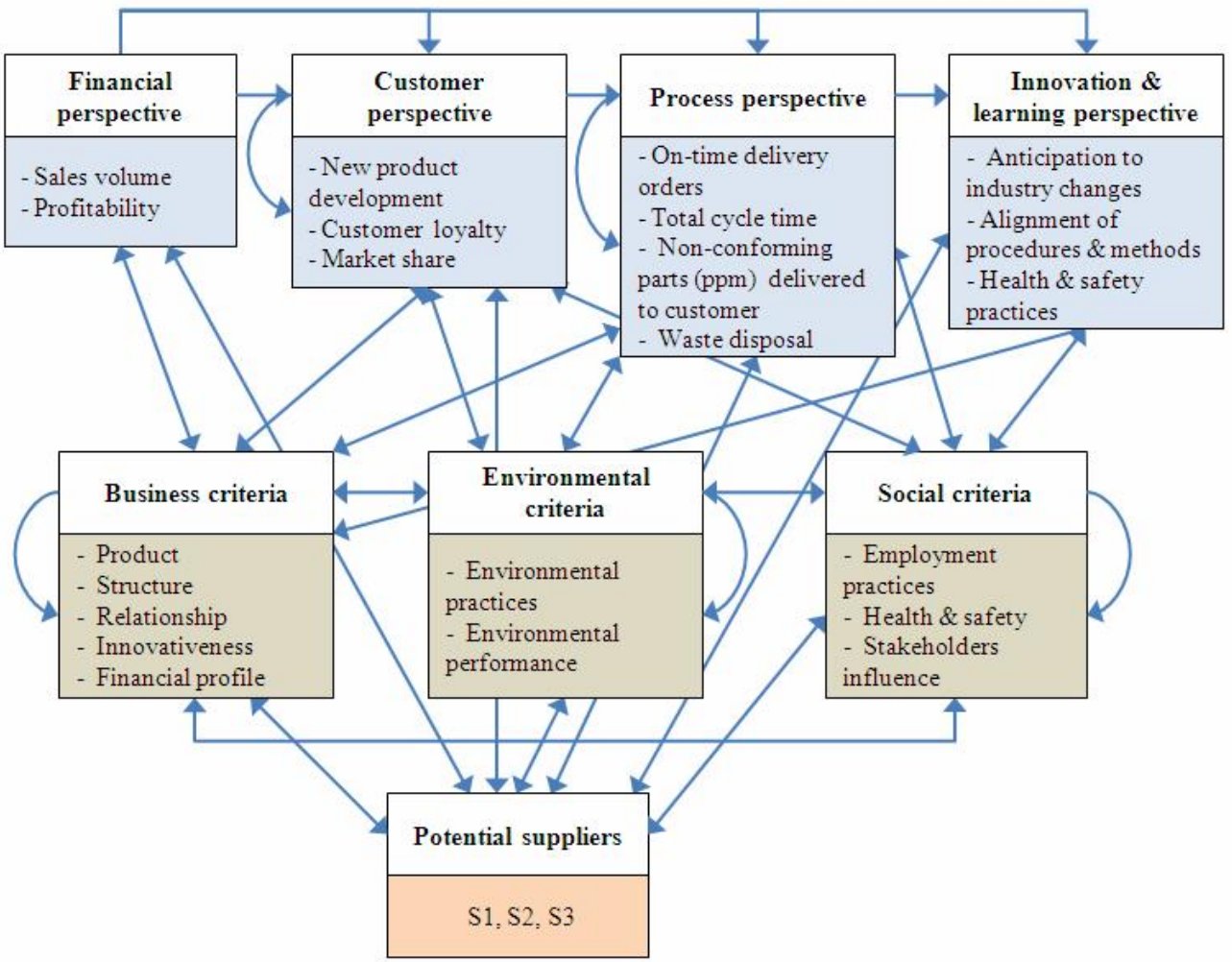
# Case study

## Phase 4. Definition of sustainability criteria

- Proposal based on literature review (sustainability and collaborative frameworks)
- 3 dimensions:
  - Business criteria: product, structure, relationship, innovativeness and financial profile.
  - Environmental criteria: environmental practices and environmental performance.
  - Social criteria: employment practices, health & safety practices and stakeholder influence.
- *Validated by the group of experts of the collaborative enterprise network.*

# Case study

## Phase 5. Building the ANP model



# Case study

## Phase 6. Making pairwise comparisons

Pairwise comparison of customer perspective KPIs with respect to profitability KPI

| | New Prod. Dev. | Cust. loyalty | Market share | Priorities |
|---|---|---|---|---|
| New Prod. Dev. | 1 | 3 | 5 | 0.1047 |
| Cust. loyalty | 1/3 | 1 | 3 | 0.2583 |
| Market share | 1/5 | 1/3 | 1 | 0.6370 |
| | | | C.R. | 0.037 |

# Case study

## Phase 7. Building the supermatrices

- Unweighted supermatrix: *Excerpt of Business criteria*

| | Product | Structure | Relationship | Innovativeness | Financial profile |
|---|---|---|---|---|---|
| Product | 0,0000 | 0,5294 | 0,3031 | 0,4874 | 0,5769 |
| Structure | 0,0736 | 0,0000 | 0,1296 | 0,1182 | 0,1807 |
| Relationship | 0,2845 | 0,1377 | 0,0000 | 0,2762 | 0,1263 |
| Innovativeness | 0,3210 | 0,2122 | 0,3889 | 0,0000 | 0,1161 |
| Financial Profile | 0,3210 | 0,1207 | 0,1783 | 0,1182 | 0,0000 |

- Cluster matrix
- Weighted supermatrix

# Case study

## Phase 8. Obtain the solution

- Limit matrix: limit priorities

KPIs

| | | | |
|---|---|---|---|
| 1 | Profitability | 0,0564 | 0,1698 |
| 2 | Anticipation to industry changes | 0,0445 | 0,1339 |
| 3 | Market share | 0,0426 | 0,1282 |
| 4 | Sales volume | 0,0417 | 0,1254 |
| 5 | Total cycle time | 0,0259 | 0,0779 |
| 6 | On-time delivery | 0,0213 | 0,0640 |
| 7 | Customer loyalty | 0,0189 | 0,0569 |
| 8 | Aligment of procedures & Methods | 0,0185 | 0,0558 |
| 9 | Non-conforming parts | 0,0169 | 0,0508 |
| 10 | New product development | 0,0164 | 0,0494 |
| 11 | Waste disposal | 0,0149 | 0,0448 |
| 12 | Health & safety | 0,0143 | 0,0432 |

# Case study

## Phase 8. Obtain the solution

- Limit matrix: limit priorities

### Sustainability criteria

| | | | |
|---|---|---|---|
| 1 | Product | 0,1505 | 0,2382 |
| 2 | Relationship | 0,0980 | 0,1552 |
| 3 | Innovativenness | 0,0754 | 0,1193 |
| 4 | Environmental practices | 0,0640 | 0,1013 |
| 5 | Financial profile | 0,0544 | 0,0861 |
| 6 | Structure | 0,0413 | 0,0654 |
| 7 | Health & safety | 0,0395 | 0,0626 |
| 8 | Stakeholder influence | 0,0388 | 0,0614 |
| 9 | Environmental performance | 0,0367 | 0,0581 |
| 10 | Employment practices | 0,0330 | 0,0523 |

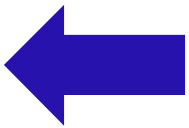
# Case study

## Phase 8. Obtain the solution

- Limit matrix: limit priorities

Suppliers

| | | | |
|---|---|---|---|
| 1 | Supplier 2 | 0,0150 | 0,4136 |
| 2 | Supplier 1 | 0,0115 | 0,3185 |
| 3 | Supplier 3 | 0,0097 | 0,2679 |



- *Validated by the group of experts of the collaborative enterprise network.*

# Conclusions

- **Supplier selection problem**:
  Alignment with a **BSC structure**.
- **Three core dimensions** for sustainability:
  **environmental, social, and economic factors.**

} *relationships*

- **Understanding** of core strategic aspects and sustainability factors that influence their enterprises: **Management.**
- The approach is applicable to **all types of inter-enterprise associations** taking into account that the performance elements definition will change depending on the specific context.
- Some **specific collaborative relationships** may consider other factors, e.g. industry specific factors.
- **Modification and adaptations (specific relationships/industry)** to be performed for these two reasons will enable to use this approach in other collaborative relationships.

# Research implications

- **International collaborative enterprise network: heterogeneity and cultural differences.**

- **Developing further a BSC that allows *integrating sustainability indicators coherently* to increase the traceability among the supplier sustainability criteria and the collaborative enterprise performance framework.**

- **Integrating the Inter-BSC with the Individual enterprises-BSC.**

- **Defining *sustainability indicators* for different sectors under common regulations.**

# Thank you for your attention!

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