Universitat Autònoma de Barcelona

2021/2022

Systems Thinking

Code: 42632
ECTS Credits: 6

Degree	Type	Year	Semester
4313489 Logistics and Supply Chain Management	OB	1	1

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

Name: Miquel Àngel Piera Eroles

Email: MiquelAngel.Piera@uab.cat

Use of Languages

Principal working language: english (eng)

Prerequisites

None

Objectives and Contextualisation

Objectives and Contextualisation

It is well accepted that a supply chain (SC) is a complex system due to the difficulty to understand the underlying dynamics and its interdependencies, which can drastically affect its behaviour, and in consequence generates uncertainty to properly coordinate the different operations.

A comprehensive systems approach is a requirement for a better understanding of the different emergent dynamics which usually appears in systems characterized by a large amount of components with tight interdependencies. Quantitative models are frequently proposed for forecasting purposes, however, they lack of supporting tools for a better understanding of the system dynamics, which sometimes requires an interdisciplinary approach to consider also the human factor.

The main objective of this subject is to introduce a causal approach to develop efficient transparent models enhancing simulation tools with the capability to explore uncertainties, trend breaks, and discontinuities; and extend their potential to foster deliberation; and their relevance to decision makers. For this purpose, students will be trained with the use of Coloured Petri Net formalism to represent the cause-effect relationships that underlies in most SC systems, and the analysis of the state space for a better understanding of the so called emergent dynamics.

The set of sub-objectives of this subject are:

- Introduce a holistic analysis approach, as opposed to reductionist, as a set of diverse interacting agents within an environment.
- Recognize that the relationships or interactions between elements are more important than the elements themselves in determining the behaviour of the system.
- Recognize a hierarchy of levels of systems and the consequent ideas of properties emerging at strategic, tactic and operational levels, and mutual causality both within and between levels.
- Introduce influence variables for a better understanding of human behaviour in a supply chain system.

Competences

- Address problems of management and coordination of logistics operations in production, transport and services in a holistic approach, by means of the consistent application of the supply chain management concepts and strategies, taking into account the pertinent aspects of environment, human capital, quality, technology, and economics.
- Analyse, organise and discuss situations in logistics in order to identify and model the dependency relationships, influence and impact that usually occur in the main performance indicators and quality factors as well as evaluating their complexity.
- Demonstrate abilities in oral and written communication both in the student's native language and in English. Demonstrate synthesis skills and ability in presentation techniques.
- Demonstrate information management skills: ability to retrieve and analyse information from different sources.
- Elaborate solid arguments based on quantitative models and analytical methods in order to convince and motivate decision makers, determine the adequate LCSM partners and then plan and coordinate the project to implement the solution.
- Select and apply the most relevant analytical methodologies, strategies and current technologies for designing solutions to the problams of management and coordination of material, information and financial flows.
- Students should be able to integrate knowledge and face the complexity of making judgements from information which, being incomplete or limited, include reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements
- Students should know how to apply the knowledge they acquire and be capable of solving problems in new or little-known areas within broader contexts (or multidisciplinary contexts) related to their area of study
- Work collaboratively in a group.

Learning Outcomes

1. Analyse complex systems with regard to their performance and sensitivity
2. Apply methods and principles of analysis, evaluation and design of LSCM systems.
3. Characterize emergent properties
4. Demonstrate abilities in oral and written communication both in the student's native language and in English. Demonstrate synthesis skills and ability in presentation techniques.
5. Demonstrate information management skills: ability to retrieve and analyse information from different sources.
6. Identify and design key performance indicators
7. Identify and model dependencies, influences and impact relationships between components of a system
8. Know methods of systems analysis.
9. Students should be able to integrate knowledge and face the complexity of making judgements from information which, being incomplete or limited, include reflections on the social and ethical responsibilities linked to the application of their knowledge and judgements
10. Students should know how to apply the knowledge they acquire and be capable of solving problems in new or little-known areas within broader contexts (or multidisciplinary contexts) related to their area of study
11. Undersantd the part in the relation to the whole.
12. Understand LSCM systems as complex structures
13. Understand the principles of systems engineering.
14. Work collaboratively in a group.
15. Work out arguments based on models and quantitative techniques

Content

THEORY

ST.T.1: Introduction to Complexity

- ST in Logistics
- Flexibility as a source of Complex Problems
- Key Parameter Indicators

ST.T.2: Discrete Event System Modeling

- Definition and concepts.
- Petri Nets: Specification of logical relationships in the logistic field.
- Coloured Petri Nets: Specification of the information flow

ST.T.3: State Space

- The reachability tree
- Cause-effect analysis
- Mitigation mechanisms of undesirable dynamics

ST.T.4: Causal Simulation Models

- Try and error approach
- Verification of Simulation Models
- Validation of Simulation Models

ST.T.5: Experimental approaches to remove non-added-value operations:

- Bottleneck evaluation.
- Policies based on the Little Law.
- Algorithm to minimize the standard deviation in manufacturing

<u>PROBLEMS</u>

ST.P.1 Examples:

- Simulation of a multimodal transport system
- Simulation of warehouse
- Simulation of an airport terminal
- Simulation of a turnaround

ST.P.2 Petri Net Exercises

ST.P.3 Coloured Petri Net Exercises

ST.P.4 CPN-Tools Exercises

ST.P.5 State Space Exercises

<u>PRACTISE</u>

ST.L.1 Introduction to SIMIO

ST.L.2 Serial Manufacturing Line

ST.L.3 Animation Modules in SImio

ST.L.4 Routing Material Flows

ST.L.5 Flowchart Simio Processes

ST.L.6 Simulation Project

Methodology

Teaching will be offered on campus or in an on-campus and remote hybrid format depending on the number of students per group and the size of the rooms at 50% capacity."

The course is organized by means of lectures. The learning process will combine the following activities:

- Theory lectures
- Problem sessions
- Practise sessions: computer lab, teamwork and oral presentation
- Autonomous work

Practical case studies and simulation tools are used for promoting students hand on skills.

The proposed teaching methodology may undergo some modifications according to the restrictions imposed by the health authorities on on-campus courses.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem Sessions	10	0.4	1, 2, 3, 7, 10, 14
Theory Lectures	20	0.8	12, 11, 13, 8, 7, 6, 9
Type: Supervised			
Practise Sessions	15	0.6	1, 2, 3, 15, 7, 10, 5, 4, 14
Type: Autonomous			
Modeling	70	2.8	2, 12, 7, 9, 10, 14
Personal Study	34	1.36	12, 13, 8, 7, 6, 9

Assessment

The proposed evaluation activities may undergo some changes according to the restrictions imposed by the health authorities on on-campus courses.

The final grade will be calculated from the assessment of different evaluation activities:

- Petri Net exercises
- State Space analysis of a case study and oral presentation.
- Simulation models and report of 2 case studies.

In order to average all the evaluation activies, the mark of each of them must be above 5 points (out of 10). All the report-based activities must be submitted within the due dates specified by the professor. If a report-based activity is failed, the student will be asked to re-submit its report according to the corrections/indications provided by the professor.

If the oral presentation is failed, the student will have the opportunity to work in a second case study for a short period of time, that will be communicated to the student well in advance.

The weights of each evaluation activity are given in the table below.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Petri Net Exercises	15%	0	0	1, 2, 3, 12, 11, 7, 10
Simulation Models	35%	0	0	2, 13, 15, 6, 10, 5, 4, 14
State Space analysis and Presentation	50%	1	0.04	1, 2, 3, 11, 13, 8, 7, 6, 9, 10, 4

Bibliography

N.Viswanadham,Y. Narahari. Performance Modeling of Automated Manufacturing Systems. Prentice Hall. 1992.

Merkuryev, Merkureva, Guasch, Piera: Simulation-Based Case Studies in Logistics: Education and Applied Research. Springer London. 2009.

Jamshid Gharajedaghi. Systems Thinking: Managing Chaos and Complexity. Elsevier.

Further readings

Javier Campos, Carla Seatzu, Xiaolan Xi. Formal Methods in Manufacturing. CRC Press 2014.

Taylor. Agent Based Modeling and Simulation. Palgrave Macmillan. 2014

N. Gilbert . Simulation for the Social Scientist.. Open University Press.

Software

CPN-Tools (https://cpntools.org)
SIMIO