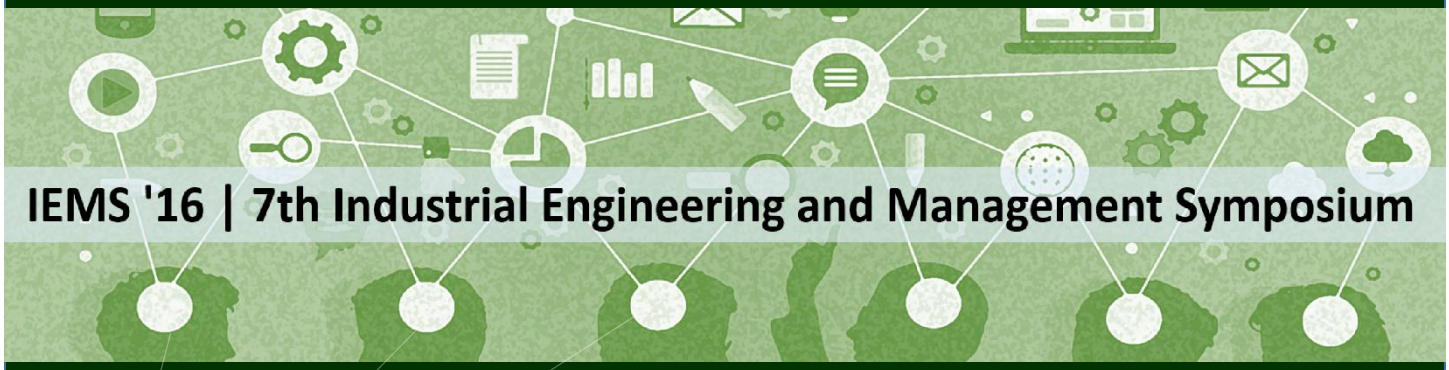

The Impact of DEGI Research on Society

Fundação Engenheiro António de Almeida
January 5th, 2016

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http://paginas.fe.up.pt/~degi/iems16

Abstracts Booklet of IEMS'16

7th Industrial Engineering and Management Symposium:

The Impact of DEGI Research on Society

Editor: Maria Antónia Carravilla

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Fundação Engenheiro António de Almeida, Porto, January 5th, 2016

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Acknowledgement of Reviewers:

Extended abstracts have been reviewed in draft form by individuals with diverse perspectives and technical expertise. The purpose of this independent review was to provide critical comments to assist the authors in making their published abstracts and their presentations as sound as possible. We wish to thank the following individuals for their reviews:

> Alcibíades Paulo Guedes, Américo Azevedo, Ana Camanho, António Brito, António Miguel Gomes, Armando Leitão, Bernardo Almada Lobo, Carlos Bragança de Oliveira, Elsa Silva, Gonçalo Figueira, Isabel Horta, João Claro, João Falcão e Cunha, João José Pinto Ferreira, Jorge Freire de Sousa, Jorge Pinho de Sousa, José António Sarsfield Cabral, José Barros Basto, José Faria, José Fernando Oliveira, José Luís Borges, José Manuel Mendonça, José Soeiro Ferreira, Lia Patrício, Luís Guimarães, Manuel Pina Marques, Maria Antónia Carravilla, Maria Dulce Soares Lopes, Maria Gabriela Beirão, Maria Henriqueta Nóvoa, Nuno Soares, Pedro Amorim, Tânia Fontes, Teresa Bianchi-Aguiar, Teresa Galvão Dias, Vera Miguéis.

and the authors that submitted to IEMS '16:

> Abílio Pereira Pacheco, Álvaro Luiz Neuenfeldt Júnior, Ana Simões, Ariane Rodrigues Pereira, Beatriz Brito Oliveira, Dario Messina, Eduardo Ferian Curcio, Eric Costa, Fábio Neves-Moreira, João Dias da Silva, José Pedro Coelho Rodrigues, Manoel Maximiano Junior, Maria João Pires, Mário Amorim Lopes, Marta Campos Ferreira, Miguel Leichsenring Franco, Nina Costa, Parisa Sadeghi, Paulo Triunfante Martins, Renata Oliveira, Sara Martins, Thiago Sobral Marques da Silva.

Although the reviewers provided many constructive comments and suggestions, they did not see the final draft of the extended abstracts before their release. Responsibility for the final content of the abstracts rests entirely with the respective authors.

Organised by:

DEGI – Department of Industrial Engineering and Management

Faculty of Engineering, University of Porto

Supported by:

Fundação Engenheiro António de Almeida

Welcome!

We warmly welcome all the attendees of IEMS'16 the 7th Industrial Engineering and Management Symposium, a joint organization of DEGI[1] and PRODEGI[2].

This symposium aims to focus on the contribution to society of the research made by the students of the doctoral program and by the researchers of DEGI. All the IEMS since the first one in 2010 have been held in emblematic sites of Porto: Casa do Infante, Museu Nacional Soares dos Reis, Biblioteca Municipal Almeida Garrett, Casa da Música, Fundação Dr. António Cupertino de Miranda and Casa das Artes e Direção Regional de Cultura do Norte. This year we must thank Fundação Engenheiro António de Almeida for providing us this venue for free.

This year, after lunch, we will have an "END to END" session with three talks involving DEGI's researchers and the partners from the companies. During this session we will have the opportunity to follow projects that involve companies and research groups of DEGI from one END to the other END.

The work of our students is however the main reason for IEMS to exist and this time all the research works that have been submitted to the symposium will be presented either as full presentations or as short "elevator pitch" presentations. The choice for the full presentations was made having in mind the different research areas within DEGI.

The following picture has been built with the text of the abstracts and is the showcase for the research that is being done in DEGI.

www.wordle.net

We wish you a fruitfull IEMS'16
The Organizing Committee

[1] Department of Industrial Engineering and Management of FEUP
[2] Doctoral Program in Industrial Engineering and Management of FEUP

Fundação Engenheiro António de Almeida, Porto, January 5th, 2016

Information for Participants

Symposium Venue

The symposium will take place at Fundação Engenheiro António de Almeida.

The venue address:

- Rua Tenente Valadim, no. 231/325, 4100 – 479 Porto;

GPS coordinates:
41.162242, -8.640161

Tel.: (+351) 226 067 418
Email: fundacao@feaa.pt

The nearest metro stop is "Francos" (1000 meters walking). There will be no private parking.

Please perform your check-in of IEMS'16 at the main lobby of the *Auditorium*. Oral communications of IEMS'16 will occur at the *Auditorium*. Coffee breaks will be served at the main hall as well.

Lunch

The lunch will be served in the restaurant of the Boavista Futebol Club Stadium on the third floor. Lunch is a courtesy of DEGI–FEUP. Please see the directions of the pedestrian path in the following map.

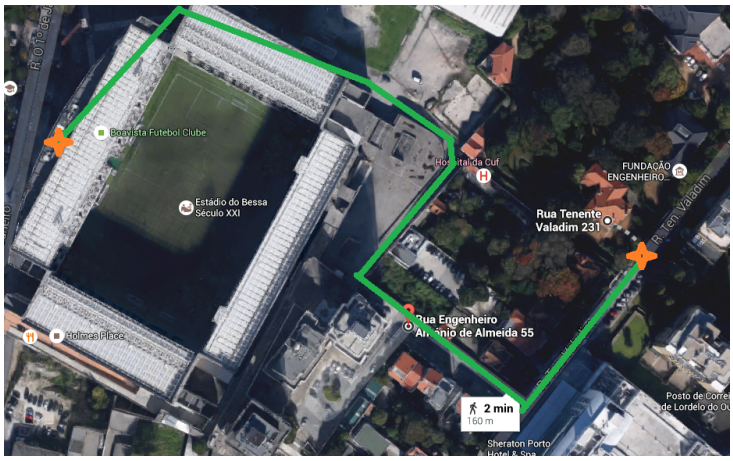

Figure 1: Pedestrian path between Fundação Engenheiro António de Almeida and restaurant of the Boavista Futebol Club Stadium.

Internet

There is Wi-Fi access in the *Auditorium* of Fundação Engenheiro António de Almeida. The Wi-Fi password will be provided to participants of IEMS'16 during the check-in.

Guidelines for Speakers

- The room is equipped with a video projector and laptop computer.
- Presentation certificates will be available at the end of the symposium.

Full Presentation and END to END

- Arrive at your session at least 10 minutes before it begins and copy your presentation to the laptop available in the room.
- Time your presentation to fit in the allotted time:

  Full Presentation: 15 minutes plus 5 minutes for Questions and Answers.

  END to END: 20 minutes plus 10 minutes for Questions and Answers.

Elevator Pitch session

- Time your presentation to fit in the allotted time: 3 minutes.
- Questions and Answers moment at the end of the session.

Guidelines for Voting for the Best Elevator Pitch Award

The elevator pitches are available in this Book of Abstracts, at the beginning of each extended abstract, and at the IEMS'16 website: `http://www.fe.up.pt/~degi/iems16`. During the breaks, the elevator pitches will also be displayed near the auditorium. A bulletin containing thumbnails of the elevator pitches will be distributed to all participants. Each participant has three votes.

Program Schedule

Tuesday, January 5th

Reception of the Participants: 8:30 – 8:55 (*Hall*)

Opening Session: 8:55 – 9:00 (*Auditorium*)

– Maria Antónia Carravilla

Chair: Gonçalo Figueira

Session A: 09:00 – 10:20 (*Auditorium*)

A.1 – Integrating fleet management and revenue management in car rental companies

Beatriz Brito Oliveira, Maria Antónia Carravilla, José Fernando Oliveira

A.2 – Information management in supply networks: a visibility model to support risk management decisions in the aeronautic sector

Dario Messina, Ana Cristina Barros, António Lucas Soares

A.3 – Planning Product-Delivery Modes For Grocery Retailers Stores

Sara Martins, Pedro Amorim, Bernardo Almada-Lobo

A.4 – Cohesive fire management within an imperfect information environment - A review of risk handling and decision support systems

Abílio Pereira Pacheco, João Claro, Paulo M. Fernandes, Richard de Neufville, Tiago M. Oliveira, José G. Borges, José Coelho Rodrigues

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Elevator Pitches: 10:20 – 11:00 (*Auditorium*)

Coffee-Break: 11:00 – 11:20 (*Hall*)

Session B: 11:20 – 12:40 (*Auditorium*)

B.1 – Effective design of backroom storage in retail food stores

Maria João Pires, Pedro Amorim, Joaquim Pratas, Jorge Liz

B.2 – Comparing Robust and Stochastic Optimization for the Lot Sizing and Scheduling Problem under Uncertainty

Eduardo Curcio, Pedro Amorim, Douglas Alem, Bernardo Almada-Lobo

B.3 – Towards an integrated approach to design for value co-creation

Nina Costa, Lia Patrício, Nicola MorelliNina Costa

B.4 – Information management for collaborative decision-making in internationalization processes of SMEs

Eric Costa, Antonio Lucas Soares, Jorge Pinho de Sousa

Lunch: 12:40 – 14:30 (*Restaurant of the Boavista Futebol Club Stadium*)

Chair: Teresa Bianchi de Aguiar

Session End to End: 14:30 – 16:00 (*Auditorium*)

E.1 – Improving the distribution master plan of a food retailer through supply chain analytics
From FEUP: Sara Martins, Eduardo Cúrcio, Pedro Amorim, Bernardo Almada-Lobo.
From SONAE MC: Rui Braz, Pedro Bártolo, João Amaral.

E.2 – Leveraging the printing plant production scheduling
From FEUP: Gonçalo Figueira, Horácio Neri, Luís Guimarães, Bernardo Almada-Lobo.
From COLEP: Daniel Lucas, Aires Ferreira, Tiago Gonçalves, Rui Neto, José Oliveira, Rui Valente.

E.3 – Shortcut - Combining Simulation and Optimization to Improve Picking Performance on Specialized Retailer Warehouse
From FEUP: João Alves, Mário Lopes, Luis Guimarães e Bernardo Almada-Lobo.
From SONAE SR: Felipe Ferreira, Gina Casal, João Silva, Manuel Fontoura.

Coffee-Break: 16:00 – 16:30 (*Hall*)

Session C: 16:30 – 17:50 (*Auditorium*)

C.1 – Forecasting the medical workforce: a stochastic agent-based simulation approach
Mário Amorim Lopes, Sofia C. Gomes, Álvaro Santos Almeida, Bernardo Almada-Lobo

C.2 – The assessement of eco-efficiency of multinational mining companies
Renata Oliveira, Ana Camanho, Andreia Zanella

C.3 – Ship design as a Complex Engineering System Design
Paulo T. Martins, António Carvalho Brito

C.4 – A mobility aware recommender system to foster the use of public transport
Marta Campos Ferreira, Ricardo Leal, Pedro Costa, Teresa Galvão, João Falcão e Cunha

Best Elevator Pitch Award and Closing Session: 18:00 – 18:10 (*Auditorium*)

– José António Sarsfield Cabral

Abstracts

Cohesive fire management within an imperfect information environment

— A review of risk handling and decision support systems —

Abílio Pereira Pacheco*§, João Claro*§, Paulo M. Fernandes†, Richard de Neufville‡, Tiago M. Oliveira†, José G. Borges♯, José Coelho Rodrigues*§

*Faculdade de Engenharia da Universidade do Porto, §INESC TEC, †CITAB, UTAD, ‡Engineering Systems Division, MIT, †Forest Protection, grupo PortucelSoporcel, ♯Forest Research Centre, ISA, U.L.

1 The Challenge

Wildfire management has been struggling in recent years with escalating devastation, expenditures, and complexity. Uncertain and highly unpredictable factors, such as weather forecasts, performance of suppression resources, and fire behavior, spread and effects are the basis of fire management and policy decisions, across multiple levels and scales. Given these copious factors and the complexity of their interactions, uncertainty in the outcomes is a prominent feature of wildfire management strategies, at both policy and operational levels.

Theoretical and computational progress in the last four decades has enabled the development of risk-based Decision Support Systems (DSS) that contribute to improve those decisions, namely by facilitating a structured assessment of the outcomes and costs associated with alternative policies, budgets, and suppression resource mixes. Improvements in risk handling and in risk-based decision support tools have therefore a key role in addressing these challenges.

In this context, we review key systems created to support wildfire management decision-making at different levels and scales, and describe their evolution from an initial focus on landscape-level fire growth simulation and burn probability assessment, to the incorporation of exposure and economic loss potential (allowing the translation of ignition likelihood, fire environment - terrain, fuels, and weather - and suppression efficacy into potential fire effects), the integration with forest management and planning, and more recently, to developments in the assessment of values at risk, including real-time assessment.

This evolution is linked to a progressive widening of the scope of usage of these systems, from an initial more limited application to risk assessment, to the subsequent inclusion of functionality enabling their utilization in the context of risk management, and more recently, to their explicit casting in the broader societal context of risks and decisions, from a risk governance perspective. This joint evolution can be seen as the result of a simultaneous pull from methodological progresses in risk handling, and push from technological progress in wildfire management decision support tools, as well as more broadly in computational power.

Seeking to characterize this movement, in a recent paper[*doi*] we identify the key benefits and challenges in the development and adoption of these systems, as well as future plausible research trends.

2 The Methodology

In recent years, several authors have updated the state of the art on the way these challenges have been addressed, organizing and aligning the sources of uncertainty with decision support tools and methodologies, in order to facilitate cost-effective, risk-based wildfire management and planning efforts. Reviewed developments include operations research methods applicable to wildfire management, and the economic efficiency analysis theory behind the fire management measures of fire management DSSs in use in America, Australia and Europe. Some of these DSSs allow the integration of wildfires into forest planning, sometimes also addressing risk and uncertainty, but broadly they include (real-time or not) wildfire simulators (autonomous or not) which in turn, were built over some surface fire spread simulation model.

Our review first assesses the characteristics of the fire modeling systems in operation (BehavePlus, Visual-Cardin used by SINAMI, FARSITE, SiroFire, Prometheus used by Burn-P3, FSPro used by WFDSS with RAVAR, FSim used by FPA, and PHOENIX Rapidfire used by FireDST) which include fire behavior, fire spread, and probabilistic fire spread simulators, and then adopts a higher-level perspective to provide a broader and more complete view of the evolution of the field. Indeed, we concisely present several important risk-based decision support models for fire management, on the one hand highlighting their usefulness within the scope and the purposes that guided their development, but on the other rendering explicit a number of limitations that they present. Some of these limitations have also been discussed recently, although in a fragmented way, in the literature on challenges in the development and deployment of risk-based decision support systems.

We bring together this set of observations, and highlight what seems to us to be an important trend of broadening of concerns from risk assessment, to risk management, to risk governance (Figure 1). This trend frames an increasingly ambitious utilization of these systems, gradually and successively broadened to address each of those areas of concern. This overall evolution pattern is the result of simultaneous methodological progress in risk handling, as well as specific technological progress in wildfire management decision support tools, and generic technological progresses in computation.

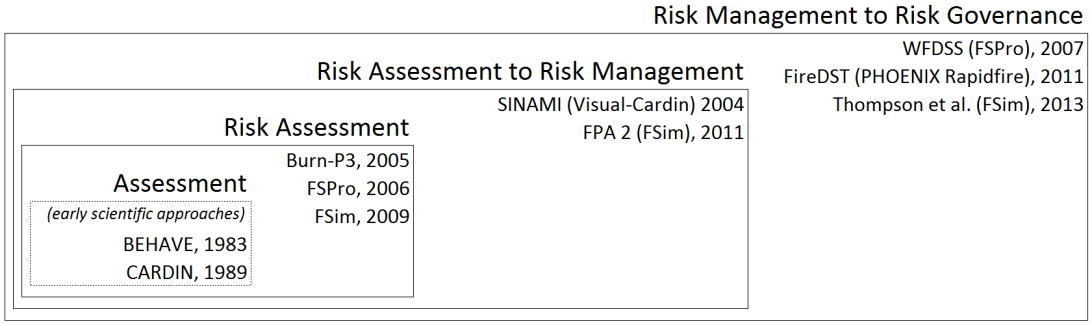


Figure 1: Conceptual outline of the expanded focus, from risk assessment to management to governance, with examples (DSSs and methodologies).

3 The value to Society

A myriad of interacting social and ecological factors influence the severity of forest fires. Thus, we need to understand the non-linear relationships between interconnected physical, biological, and cultural systems to be able to effectively reduce the vulnerability of ecosystems and human societies, through improved and proactive risk governance. Problem structuring methods, system dynamics, simulation, decision analysis, and optimization, together with qualitative methods such as expert elicitation, open interviews, questionnaires, and surveys, can help model the dynamics and advance the understanding of these complex systems, gaining insight into problem structures, and better enabling the exploration of alternative management options, in face of always present budgetary constraints.

The integration of forest fire risk concerns into forest planning processes is a significant step. However, more research is needed characterizing the impacts of alternative fire management options on market and nonmarket values at risk, and on the economic losses in goods and services triggered by the fire consequences that they try to mitigate. Risk-based analysis is required for the integration of risk handling and fire management, in order to improve the prioritization of future efforts to mitigate the risks associated with these natural and human caused disturbances. Risk assessment should also identify and characterize the importance and weight of uncertainties to improve the management of human and ecological resources at risk, in areas ranging from fuel mapping to how society values those resources.

Our review of DSSs in current use stresses the importance of the integration between risk handling and DSS development, to facilitate and improve the quality of decisions under uncertainty, and enable a cohesive fire management in an uncertain environment. It also points out the importance of understanding the institutional constraints of management programs within which forest fire mitigation programs develop, that along with ecological constraints, the need to engage multiple stakeholders, and the need for adaptation to local contexts, must be reflected in the usability and flexibility of these systems. In the case of Portugal, our work may also contribute to address the lack of a DSS in use.

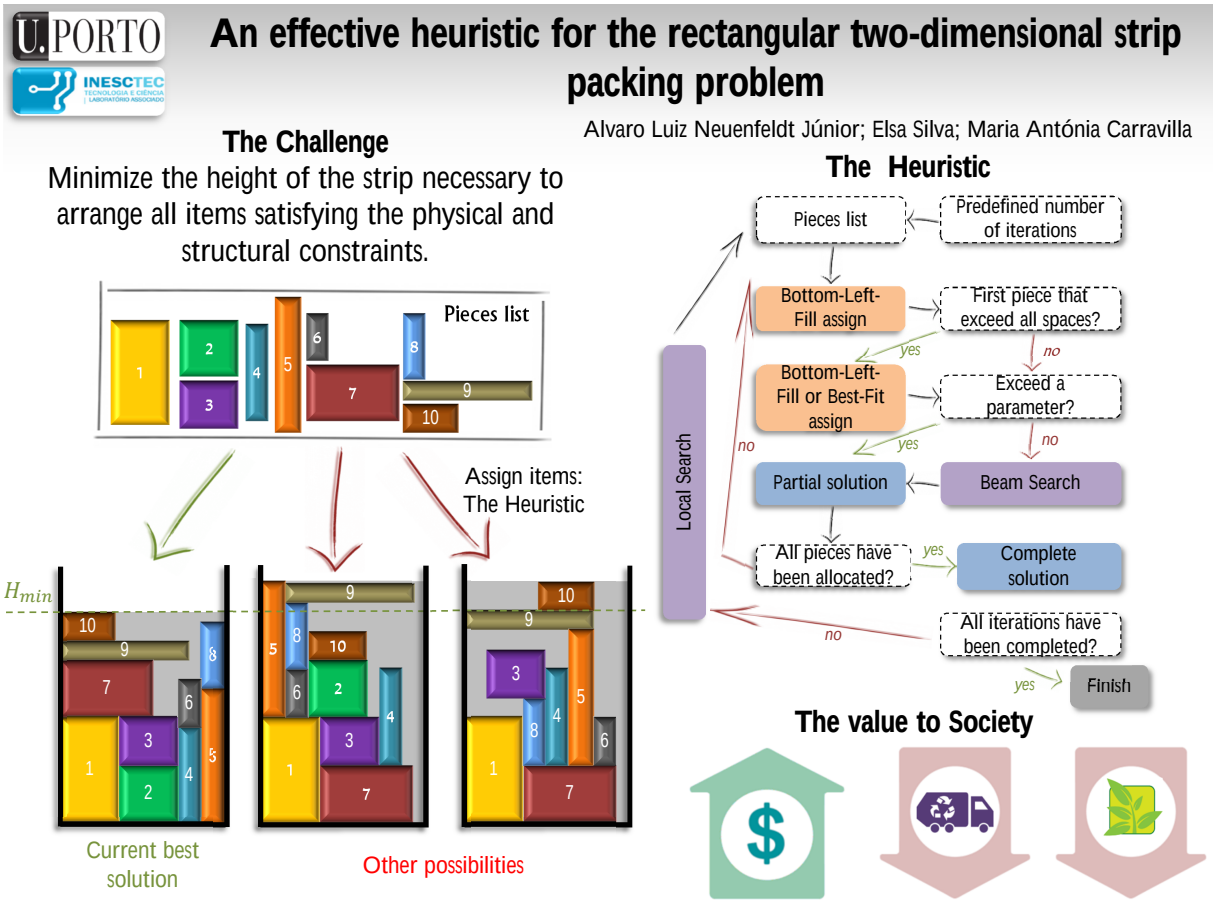
Acknowledgements

This work is financed by the ERDF through the COMPETE and by National Funds through the FCT within project FIRE-ENGINE/MIT/FSE/0064/2009 and grupoPortucelSoporcel; and by project UID/EEA/50014/2013. FCT also supported the research performed by Abílio Pereira Pacheco (Grant SFRH/BD/92602/2013). Our work greatly benefited from the many colleagues acknowledged in the paper[doi].

An effective heuristic for the rectangular two-dimensional strip packing problem

Álvaro Luiz Neuenfeldt Júnior*§, Elsa Silva*§, Maria Antónia Carravilla*§

*Faculdade de Engenharia da Universidade do Porto, §INESC TEC



1 The Challenge

The search for the best arrangement of a set of small items in a large object is defined in the literature as a Cutting and Packing problem. The problem can derive from different industries and can have several specificities depending on the application where it emerged from.

The present study was conducted in order to determine the best way to place a set of small rectangular items into a large strip, with a predefined width and infinite height, minimizing the total height used. This problem can be found for example in the textile industry, and it is known in the literature as Two-Dimensional Strip Packing Problem (2D-SPP).

The challenge is to minimize the height of the strip necessary to arrange all items satisfying the physical and structural constraints. An example can be found in Figure 1.

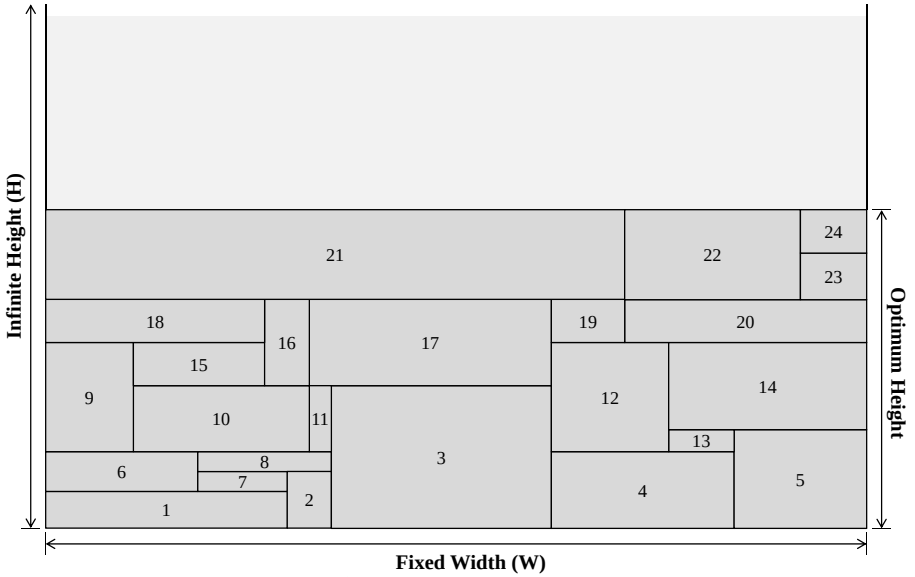


Figure 1: A general view of the 2D-SPP.

The pieces and the strip have rectangular shape and the pieces should be placed orthogonally, without any overlap and rotation. Regarding the types of cuts that can be performed into the strip, it will be considered the guillotine version, in which the cuts must be performed from edge to edge parallel to the sides of the strip and also the non-guillotine version, where the cuts are not restricted by some machines cutting conditions.

2 The Methodology

The 2D-SPP is an NP-hard combinatorial optimization problem, i.e. as the instance size grows, the computational time required to solve optimally the problem increases exponentially. In the literature, the methods applied to solve the problem are both exact and heuristic. Our contribution is on the development of an efficient heuristic able to solve very large problem instances. The new heuristic will be based on Local Search techniques, due to its capacity of quickly finding neighbour solutions in the feasible search space.

For each piece allocation a deterministic Bottom-Left-Fill (BLF) constructive algorithm, where the pieces must be placed into an available specific position in the assembly (named as space), as far down and to the left as possible. When the first piece exceeds in width all spaces available, the Best-Fit (BF) approach is triggered to compete with the BLF, in a manner that the input order depends on the arrangement of the partial solution, and the piece fit better than the BLF. The selection of one of these construction forms is directly related to the layout before the piece allocation and must be activated for all the pieces available allocate. A scheme of the heuristic proposed can be found in Figure 2.

This approach does not need a pre-tuning of the parameters and was developed with the objective of obtaining the best fit between the available rectangles spaces and the pieces to be positioned.

For the final assigning steps the use of the Beam Search heuristic was proposed. The Beam Search is a heuristic that explores the potential of partial solutions by expanding the most promising node at each allocation step, and starts when a predefined parameter value, related with the number of pieces already placed, is reached. The objective is to explore more efficiently the set of partial solutions available, in order to find the solution with higher potential to reduce waste in the pieces assignment to the free spaces. If all pieces have been placed, a complete solution is generated and it is compared with the solutions found in previous iterations, obtaining the solution with the smallest height.

To test the heuristic method developed, a set of instances from the literature was used, based on industrial applications, validating the solutions found and its level of effectiveness.

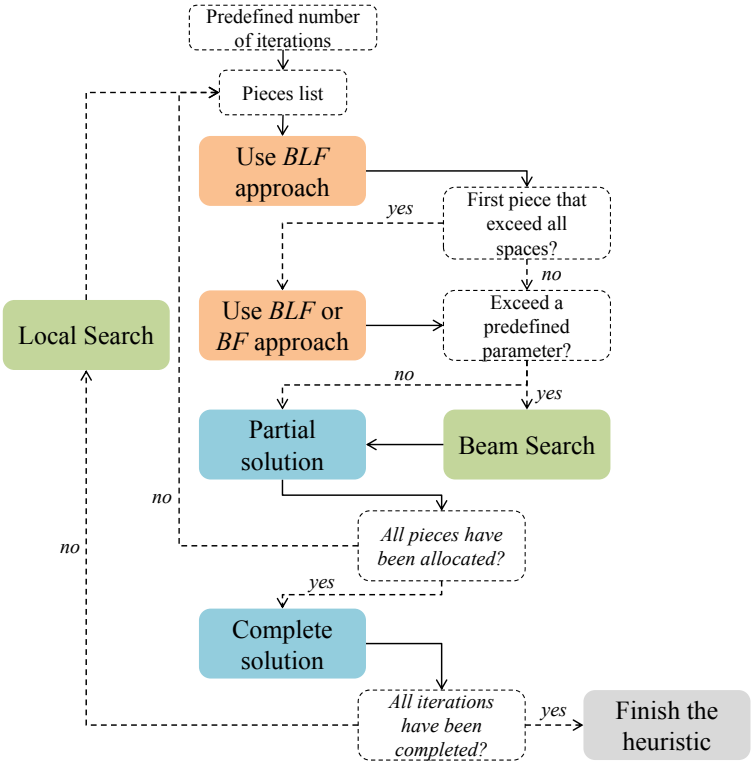


Figure 2: Heuristic steps.

3 The value to Society

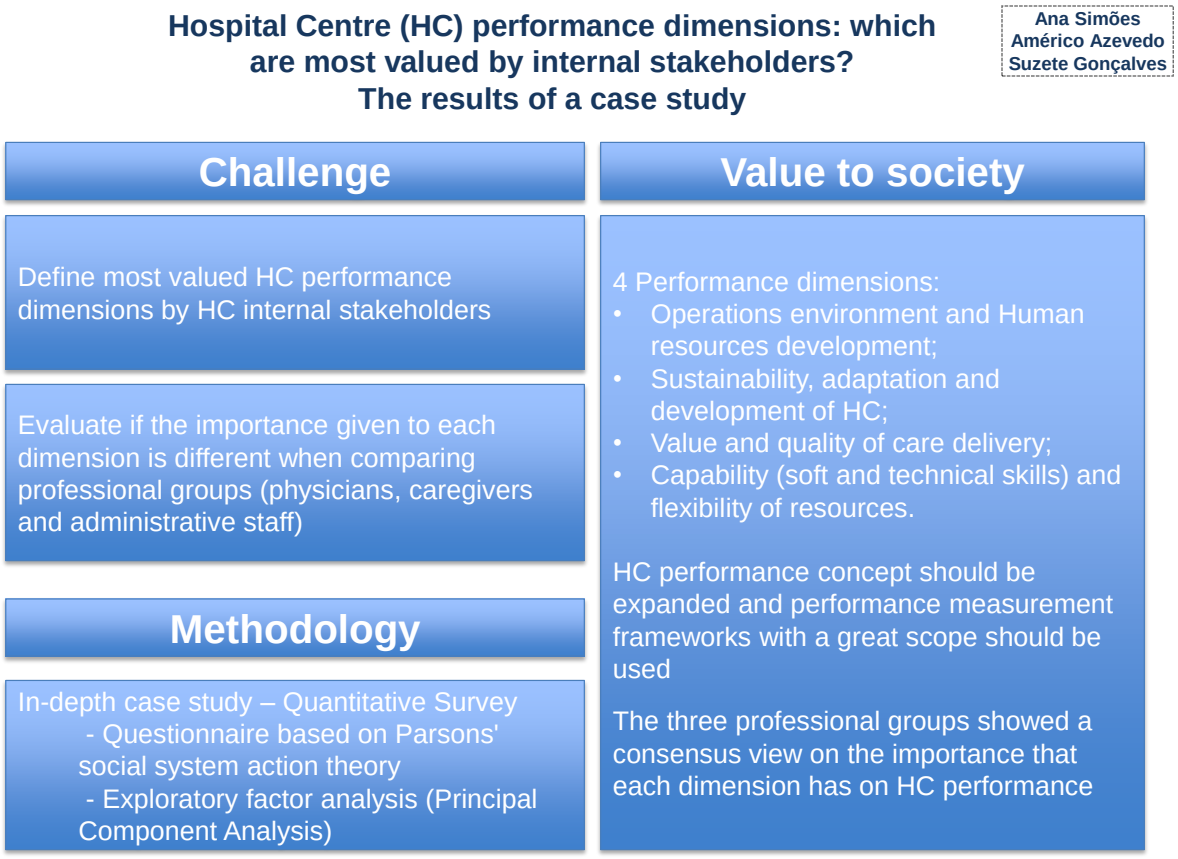
The 2D-SPP can be found in many industrial applications, such as the Very-Large-Scale Integration (VLSI) layout design, the sheet metal industry, where the rolls are divided into rectangular items, the textile industry, where the fabric should be cut in smaller pieces, in an optic fiber communication, during the memory allocation storage process and also an indirect application in scheduling problems.

In these problems the main objective is to reduce the waste of the material used to satisfy the demand. In fact, the use of optimization methods, in particular efficient heuristics as the one that it is proposed, is of major importance for these industries. Besides, the reduction of the raw material consumption contributes to the reduction of the environmental impact of these industries which is undoubtedly an important value for the society.

Hospital Centre performance dimensions: which are most valued by internal stakeholders? The results of a case study

Ana Simões*§, Américo Azevedo*§, Suzete Gonçalves†

*Faculdade de Engenharia da Universidade do Porto, §INESC TEC, †Centre of Research in Health Studies, University of Coimbra



1 The Challenge

The Portuguese organizational model, created in 1999, called Hospital Centre (HC), follows the horizontal integration model, and consists of integrating two or more hospital units. Horizontal integrations have been conducted between hospital services in the Portuguese health system. The benefits of this type of integration have been presented in the literature. However, few studies on the Portuguese HC experience have been published, and no study was published regarding the performance dimensions of hospital care organizations, and in HC in particular.

The variety of models of healthcare performance reflects different and fragmented aspects of performance. Three main domains are commonly included in the debate in healthcare management literature: quality

of healthcare delivery, effectiveness in healthcare delivery and financing and accountability of health organizations. A consensus regarding the best model to assess performance is impossible to obtain. Individuals? values and preferences holing for a certain organization are the main contribute for the performance judgments. These values and preferences vary between, and often are contradictory, among the different stakeholders. Some authors developed models where they tried to integrate the different dimension of performance.

According to the multiple constituent model of organizational performance, the stakeholders' perspectives must be considered in an integrated way for the purposes of evaluation. Therefore, a comprehensive theoretical grounded framework was developed that overcomes the fragmented approach assess the healthcare organizations performance. This framework is based on the Pearson's social system action theory which combine the four dominant models for the evaluation of organizational performance: rational, open system, internal process and human relations.

Based on this analytical framework, a survey was developed to define hospital performance among key stakeholders in hospitals. This survey was applied to the Belgian hospital leaders focusing on their conceptualization of hospital performance. Lately, an adapted version of this survey was applied to a teaching hospital in France. The aim of this study was to find emerging views on hospital performance. Subsequently, the adapted version of this survey was used to examine and compare the views on the performance of internal stakeholders in an Italian network for oncological care. More recently, the adapted version of the Belgian survey was applied to an Italian teaching hospital located in the Calabria region.

Performance measurement frameworks for HCs considering the internal stakeholders valued dimensions have, to the best of our knowledge, not been proposed yet. This study aims at defining most valued HC performance dimensions by HC internal stakeholders, and to evaluate if the importance given to each dimension is different when comparing professional groups (physicians, caregivers and administrative staff).

2 The Methodology

Towards the identification of the emerging views on performance dimensions of HCs and to analyze how these views vary among HC internal stakeholders, we conducted an in-depth HC case study using a quantitative survey. The survey uses a questionnaire based on Parsons' social system action theory, which includes the four major models of organizational performance mentioned above.

The survey used in this study was an adaptation of the Belgian and French surveys. After the content validation it was possible to make improvements to the survey, and a final set of 67-item to measure hospital performance was defined.

The scale used in this study was the same as that used in the previous studies. To measure the answers we used an interval scale from 0 to 10, where 0 was not important at all and 10 was extremely important.

The survey was conducted between January and March 2015 with all HC staff.

An exploratory factor analysis was conducted for a final sample of 365 participants, through principal component analysis (PCA), to identify the empirical structure of the questionnaire. Since the correlation between factors was taken into account, a direct oblique rotation was used. The Kaiser criterion was used to establish the number of factors extracted.

To compare the relative importance of the four dimensions (factors), we conducted the paired sample T test for each pair of dimensions (factors). Additionally, to evaluate if the importance given to each dimension is different when comparing professional groups, we performed a one-way analysis of variance for the equality of means.

This first EFA identified eight factors that explained 73.52 percent of the total variance. This factor structure contained many items with loadings below 0.4 and also many items with high cross-loadings. Subsequent PCAs were performed eliminating all the items with loadings < 0.4. We reached a factor structure with 37 items. The overall explained variance was still satisfactory 67.79 percent. For this model the KMO test was 0.964 denoting a very good correlation between variables.

In this study four factors were retained: Operations environment and Human resources development; Sustainability, adaptation and development of HC; Value and quality of care delivery; and Capability (soft and technical skills) and flexibility of resources. Three of them are equally important to the internal stakeholders. Only the Sustainability, adaptation and development of HC dimension was viewed as less important comparatively to the other three.

A shared view was found in this study among the three groups of internal stakeholders: physicians, caregivers and administrative staff, since there were no statistical differences when factor score means were compared between groups.

3 The value to Society

In this study four factors were retained: Operations environment and Human resources development; Sustainability, adaptation and development of HC; Value and quality of care delivery; and Capability (soft and technical skills) and flexibility of resources. Three of them are equally important to the internal stakeholders. Only the Sustainability, adaptation and development of HC dimension was viewed as less important comparatively to the other three.

These results confirmed that internal stakeholders are extremely concerned with HC resources aspects, namely human resources and their importance for the HC to perform well. The relation between HC professionals and their patients and the community is also considered an important aspect of HC performance. HC internal stakeholders also considered that their involvement in finding solutions to HC performance problems is an important aspect. A good and healthy work environment is considered an important aspect for an excellent performance.

Value and quality of care delivery is also valued by internal stakeholders. This dimension reflects the concerns regarding a better use of resources, which should be used to respond to the real needs of patients and to guarantee the medical specialties that the community needs. The evaluation of the quality of care provided is also viewed as an important aspect for an HC to have an excellent performance. In terms of performance, according to internal stakeholders it is important to continuously improve HC resource utilization and the quality of the care provided to patients.

The three professional groups shared a common opinion regarding the four performance dimensions. The three professional groups showed a consensus view on the importance that each dimension has on HC performance. It seems that the austerity environment, with big financial constraints, which induces competitive views between administrative staff and physicians, in this case causes great concerns among internal stakeholders. This fact may have contributed to this shared view.

This study evolves all professional groups inside the HC, thus making it possible to explore a broad internal perspective of the performance dimensions most valued by HC internal stakeholders. Some dimensions found in this study are not usually available in hospital care units. Another great advantage of this study is the voluntary participation of internal stakeholders, since no compensation was given to participants, nor was participation mandatory. In fact, participation in the survey was only intrinsically linked to the survey's topic and the level of interest in the topic among HC internal stakeholders.

Our findings suggest that the HC performance concept should be expanded and performance measurement frameworks with a great scope should be used. Thus, the HC comprises the internal units (services, departments) that add value to patient as they progress through an integrated organization. Like other organizations, the success of an HC depends on integration, coordination, communication and cooperation between departments/services and appropriate, performance measurement and management is essential if the HC is to attain a better use of resources, a better care delivered, a satisfied patients, a better quality and access to patient and community and a motivated staff. These results challenge the traditional performance measurement frameworks. Developing a performance measurement framework for such a horizontally integrated hospital care delivery organization is a challenge task.

These results confirmed that the performance dimensions for the HC include other domains besides the traditional domains of quality of healthcare delivery, effectiveness in healthcare delivery and financing and accountability of health organizations. The human resources development, the Capability (soft and

technical skills) and flexibility of resources are important dimensions to consider in the performance measurement of the HC.

An exploratory analysis of the role of Technology Roadmapping, Lead User and Technology Product Market in the Front End of Innovation

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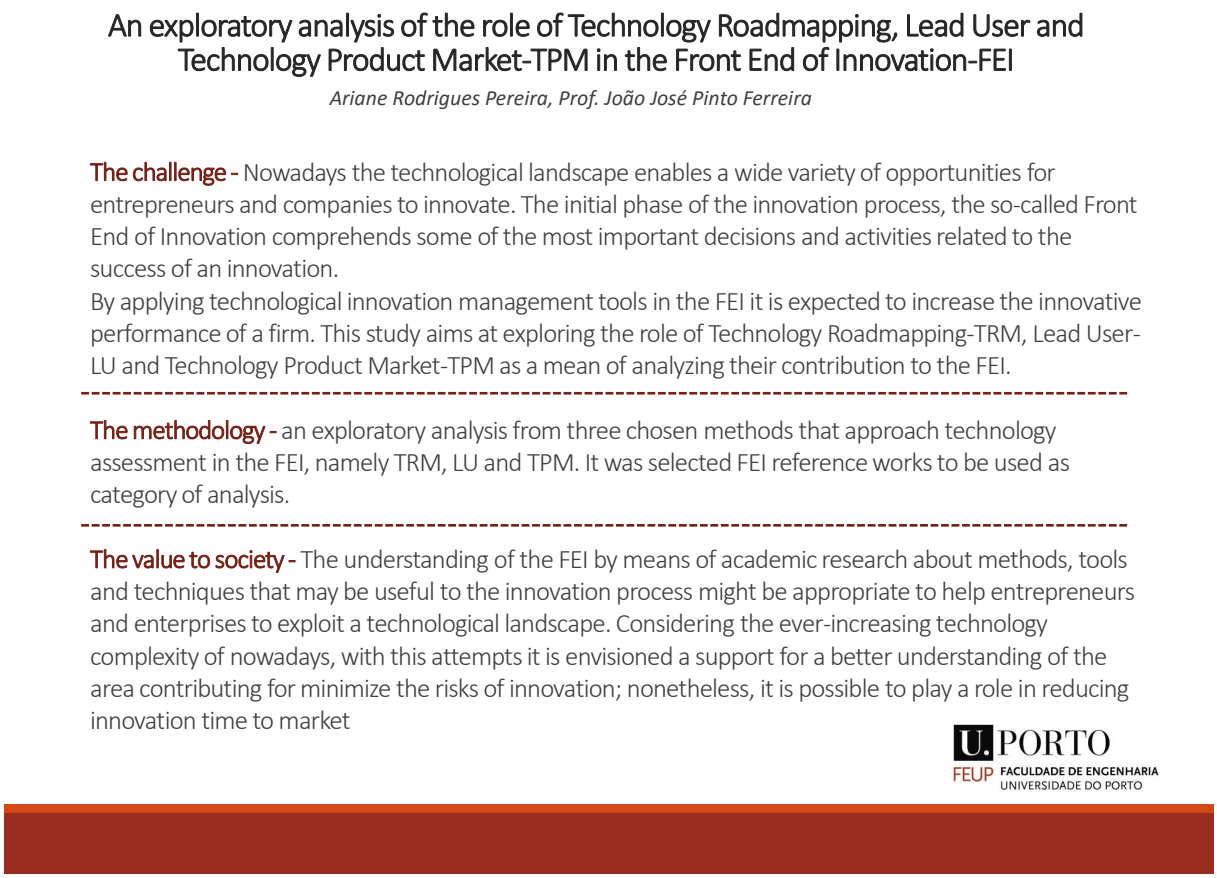

1 The Challenge

Currently the technological landscape enables a wide variety of opportunities for entrepreneurs and companies to innovate. The initial phase of the innovation process, the so-called Front End of Innovation comprehends some of the most important decisions and activities related to the success of an innovation. The innovation process includes the predevelopment phase - the Front End of Innovation (FEI), the New Product Development and the Commercialization phase.

The FEI tackles activities related to idea management (e.g., idea generation, idea enrichment, idea selection) opportunity issues (opportunity identification, opportunity analysis, opportunity timing, preliminary technology and market analysis) and concept definition. This phase of the innovation process is

directly affected by organizational capabilities, structure and culture; also, business, technology and innovation strategy. In addition, uncontrollable issues such as legal, political, technological and economical, influence the FEI.

By applying technological innovation management tools in the FEI it is expected to increase the innovative performance of a given firm. Therefore, the research question that lead to this exploratory study was the following: Which is the role that TRM, LU and TPM play in the FEI?

Considering this scenario, the objective of the present study is to explore some technological methods in order to contribute to opportunity issues in the FEI. Therefore, this study aims at exploring the role of Technology Roadmapping (TRM), Lead User (LU) and Technology Product Market (TPM) as a mean of analyzing their contribution to the FEI.

The results suggest that TRM, LU and TPM have a strong presence in the FEI. They are useful for exploring opportunity issues, such as the opportunity identification and the opportunity analysis. They are suitable for the phases related with ideation, project interface and help to build business cases. The lack of emphases evidenced for TRM and LU is related to the internal organizational concepts, such as leadership, culture and organizational structure.

2 The Methodology

The method carried out to achieve the research's objective was an exploratory analysis from three chosen methods that approach technology assessment in the FEI, namely TRM, LU and TPM (see Table 1, pg. 2). It was selected FEI reference works to be used as category of analysis. Therefore, the methods were analyzed according to the NCD Model, Stage Gate®Model considering only FEI phases, a model of NPD Front End and Fuzzy Front-End Information Flow and Decision-Making Process.

3 The value to Society

The understanding of the FEI by means of academic research about methods, tools and techniques that may be useful to the innovation process might be appropriate to help entrepreneurs and enterprises to exploit a technological landscape. Considering the ever-increasing technology complexity of nowadays, with this attempt it is envisioned a support for a better understanding of the area contributing for minimize the risks of innovation; nonetheless, it is possible to play a role in reducing innovation time to market.

Table 1: Analysis categories for TRM, Lead User and TPM.

Method	Analysis Categories
Technology Roadmapping	Phase of Identification of the needs and drivers
	Identifying of products or services to meet the needs and the drivers
	The identification of technologies to support the products or services
	Establishment of the links with the first three steps
	The development of plans to acquire or develop the technologies
	Relating resources to achieve the plans for acquisition and development
	Technology Roadmapping - TRM Initiation
	Subject selection
	Technology needs assessment
	Development of Technology plan
	TRM implementation
	Follow-up activity
	Environmental scan
	Organizational scan
	Emergence roadmapping
	Collaborative research strategy framework
	Preliminary activity / Initiation / Preliminary activity / Preparation
	Development of the roadmap / Development / Tech roadmap development / Implementation
	Follow-up activity / Integration / Follow-up activity / Finalization
Lead User Technology	**Definition of a front field.** Lead User are at the forefront of an important market trend
	Identification of important needs and trends. Lead User have a high need for solutions in what comes to the novel needs they have encountered at that forefront
	Identification of lead users and ideas. Lead User in innovation management to contribute for management decision making
	Identification of lead users and ideas. Lead-user in technology foresight to contribute into management decision making
	Development of innovative concepts (lead user workshops). Lead Users incorporated in product and service development
Technology Product Market	Converting Technical Specifications into Capabilities
	Turning Technology to Product Elaboration
	Product to Market Elaboration
	Personal and Implementation

Integrating fleet management and revenue management in car rental companies

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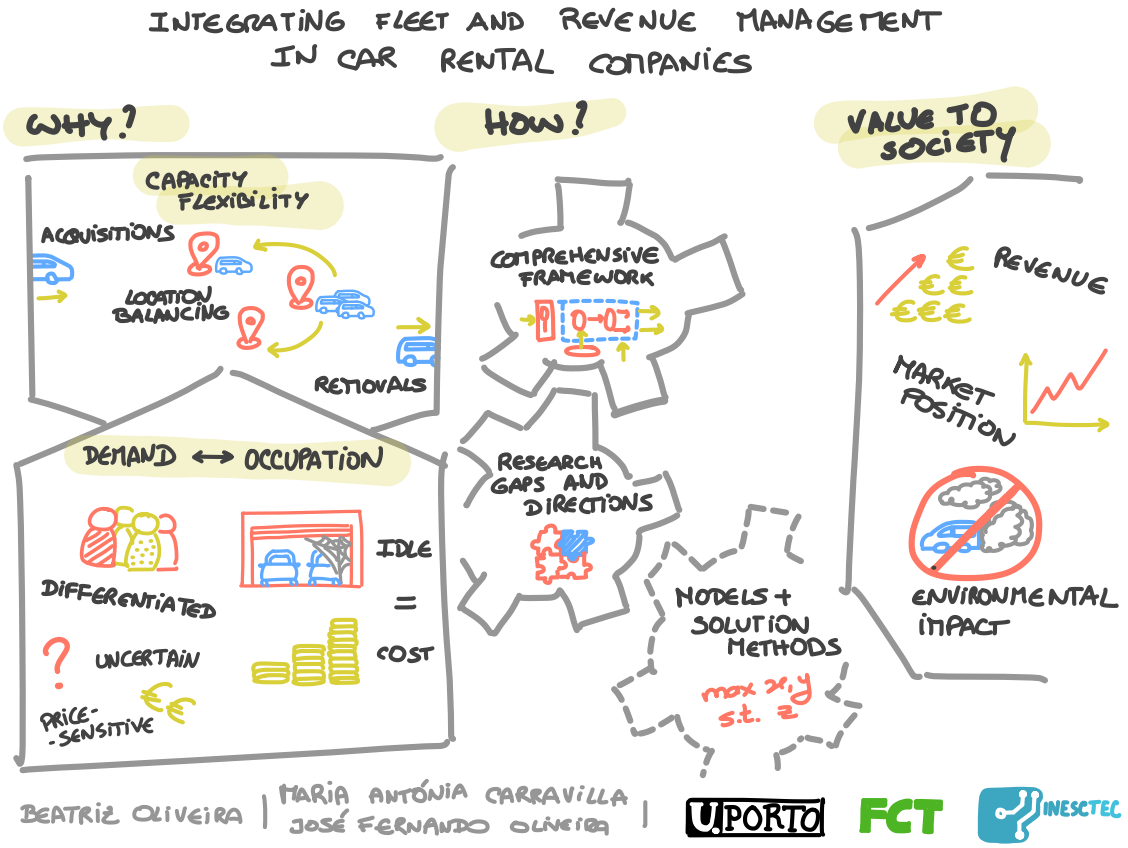

1 The Challenge

The car rental business is heavily dependent on operational efficiency, due to the intense competition in the market and the actual cost structure of the business, which is based on the trade-off between occupation and availability (service level). The fleet management decisions of a car rental company belong to different strategic/operational levels. The main decisions are: clustering of the rental stations in fleet-sharing pools (pool segmentation), deciding the fleet size and vehicle mix for each pool (fleet size and mix), balancing the fleet levels among the different rental stations (fleet deployment), and scheduling/assigning reservations and maintenance requirements to specific vehicles (fleet assignment). At the same time, the problem of capacity allocation (deciding how much capacity to protect for each customer segment, in car rental usually framed as "accept/reject" decisions for each type of booking request) has also been tackled in this industry, namely with revenue management techniques such as booking limits, bid prices, or overbooking. This follows the seminal experiences with revenue management in the airline industry.

In order to understand the importance of integrating fleet management and revenue management in car rentals, it is important to acknowledge the two main drivers of revenue in car rental companies: demand

– highly dynamic, uncertain and price-sensitive – and occupation levels – the main slice of operational costs being heavily grounded on idle vehicles. These two drivers are intertwined and both depend on fleet management as well as revenue management decisions. In fact, revenue management decisions include not only capacity allocation but also pricing, although the amount of research in the latter stream is scarce within the car rental context.

Moreover, one important idiosyncrasy of the car rental business that supports these integration efforts is the high flexibility of the resources, not only in terms of mobility but also in terms of quantity. Unlike airline transportation, capacity can be easily deployed between locations and it is also easier and faster to acquire and remove vehicles from the fleet.

Currently, on the one hand, there is a growing attempt in the literature to integrate revenue management and fleet management decisions, yet only limited to capacity allocation and fleet deployment within a narrow scope. On the other hand, in the business day-to-day practice, there has been an effort to further develop this integration and, more recently, to extend it to other fields of revenue management and fleet management. In fact, setting prices dynamically in accordance to the market positioning is becoming critical, as well as developing better tools for fleet management at a pool level that include acquisitions/removals decisions in a more realistic framework.

In conclusion, the aim of this work expands beyond combining two traditionally separate problems (capacity controls and/or pricing – under the revenue management framework – and operational car rental fleet decisions). The goal is to build an holistic fleet management problem structure that accurately depicts the links between the several sub-problems and facilitates a more realistic approach.

2 The Methodology

The first step was to structure the fleet management problem in the car rental context (including the revenue management issues) in a more holistic yet detailed "map of action". That is to say, to consider, structure and frame the interactions between the usually isolated sub-problems tackled by the companies, structuring a framework that is business-oriented rather than methodology-oriented (i.e. more focusing on the company's issues/decisions than attempting to provide mutually exclusive and completely exhaustive categories that contain the research done in this field). Building on this framework, it will be possible to identify which decisions should be integrated and how this integration could be implemented (e.g. hierarchical approach, two/multi-stage programming, or fully-integrated model).

The main goal of this framework is to open possibilities of research. Therefore, although it will be used to categorize the existing literature and identify research gaps, it structure itself can provide some cues onto interesting research directions. To achieve this, there is an attempt to follow the flow of the business decisions and to avoid restricting the decisions based on factors that in this business are flexible, such as the decision time horizon or the geographical level of decisions. The only "geographical" decision considered is the pool segmentation, since it is a building-block that can be easily disregarded if one chooses to tackle the rental stations as a whole group and not divided in pools. Figure 1 shows a simplified overview of the overall framework.

The different building blocks are connected by their inputs/outputs, often in overlapping decision time horizons. Also, the key characteristic – flexibility – is present throughout the business process. In fact, most decisions are not "rigid" and can be frequently updated, from the most strategic ones, such as pool segmentation, to the most tactical ones, such as fleet assignment. That can be represented with adequate feedback loops. Moreover, there is a general input to the process, the demand, which includes not only unconstrained and constrained demand modelling/forecasting but also realistic issues such walk-in customers, no-shows and cancellations. The modelling of this core input is itself a research stream most relevant in this field. From a complete and detailed view of this framework, together with an analysis of the existing literature, it is possible to identify potential research interests.

The following step is to properly model and solve the integrated problem, tackling the curse of the car rental flexibility – dimensionality. To do so, mathematical models and algorithms will be developed.

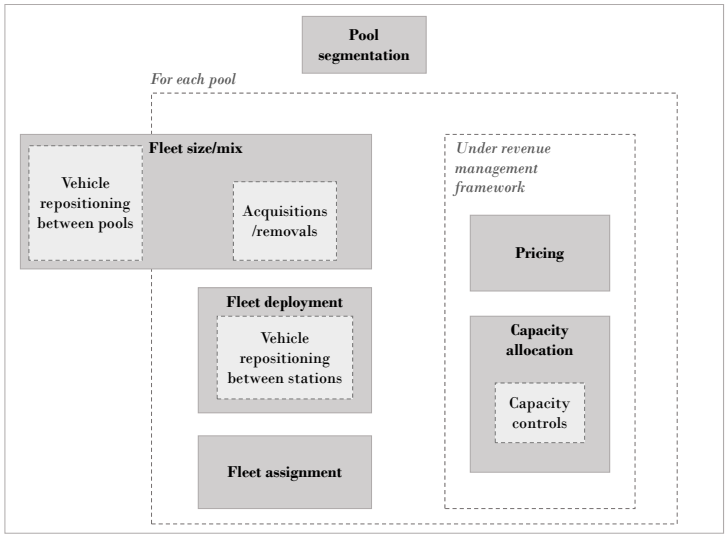

Figure 1: Simplified overview of the framework for the car rental fleet (and revenue) management problem.

3 The value to Society

The main contribution of this work is the proposed framework for the overall fleet management problem, that considers the integration with revenue management issues, and is able to pinpoint interesting research streams. This framework is different from the "status quo" in the field not only because it integrates capacity allocation and, especially, pricing issues but mostly because it is based on a business-oriented perspective of the problem. It aims to present an holistic view of how the sub-problems are interconnected rather than provide a categorization for the existing literature. For example, this framework leads to a perspective on fleet size and mix that includes more detailed decisions, namely acquisitions and removals, building on the capacity flexibility of the industry.

The value to society can be seen from the perspective of the company, which will be able to increase its revenues through increased operational efficiency and profit realization, and therefore improve its market position. The market position will also be more controlled, due to the "pricing building-block", since it requires a dynamic monitoring of competitors and other forces at play in the market. The other perspective on operational efficiency is a better utilization of resources. More specifically, through better vehicle repositioning, an improved utilization of the fleet, and a better policy for acquisitions and removals, it will be possible to reduce the environmental impact of these transportation activities.

Acknowledgements

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Information management in supply networks: a visibility model to support risk management decisions in the aeronautic sector

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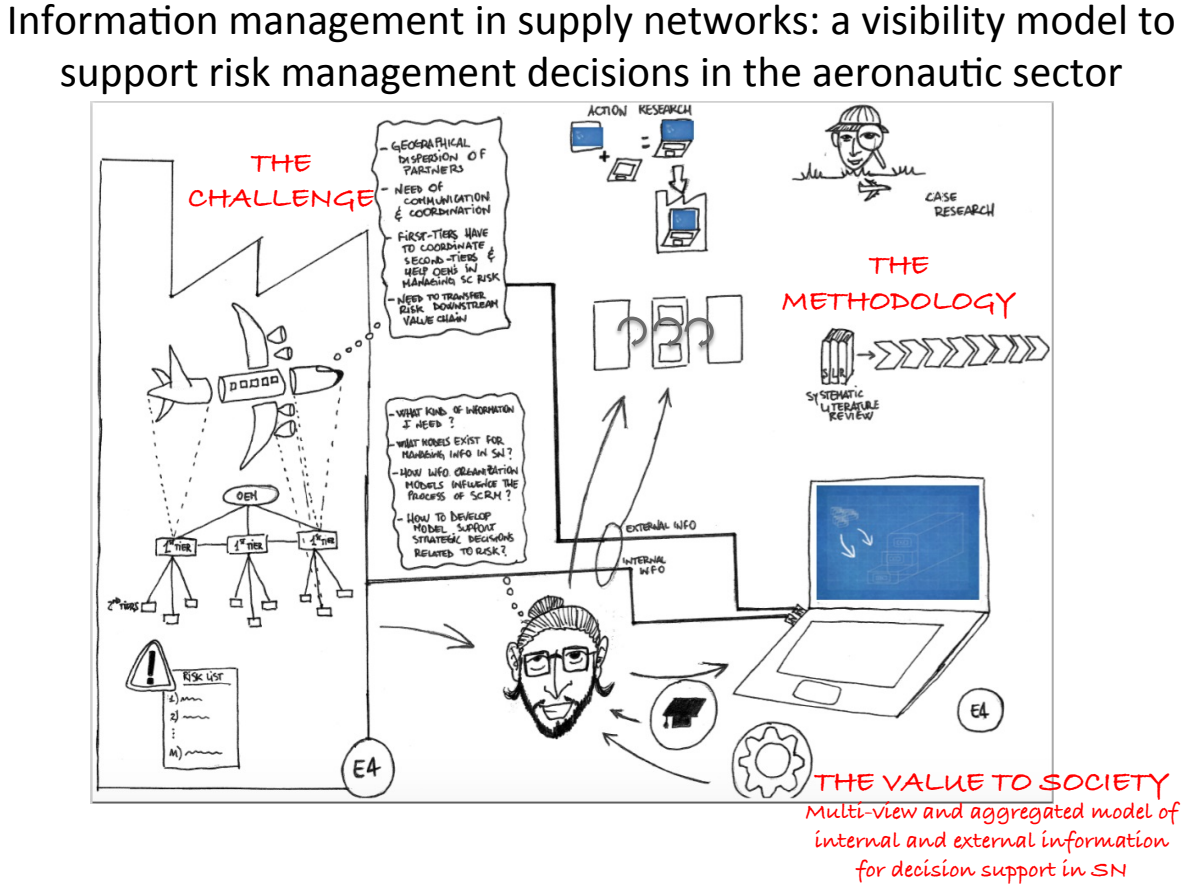

1 The Challenge

In today's global business environment, supply chains have increased in both length and complexity, due to greater uncertainties both in supply and demand, and shorter technology life cycles. This is also the case of the aeronautic supply chain, which is becoming even more complex and consequently has higher levels of supply chain risk. These changes call for more research on how supply chain risk is being managed, and how internal and external information should be managed among supply chain partners to support risk management related decision-making.

Companies value the importance of establishing a risk management process to identify, measure, mitigate, and control risks in their supply network. In order to be able to identify these risks, companies are starting

to work with their network partners towards creating supply network visibility. The objective of this work is to respond to this challenge by developing a multi-perspective and multi-viewpoint visibility model of the supply network that support strategic decision-making in order to assess the risk along the whole chain. The main innovation in the visibility model is the capability to integrate and organise internal and external information (regarding the supply network) in a way that is adapted to each node in the network and according to the types of risks.

2 The Methodology

This work follows the Design Science Research paradigm, whose structure applied to our context, is showed in Figure 1. This research paradigm was chosen because its ultimate goal is to guide research that aims at developing artifacts - in our case an information model - that, once tested, are able to provide innovative solutions for specific business needs.

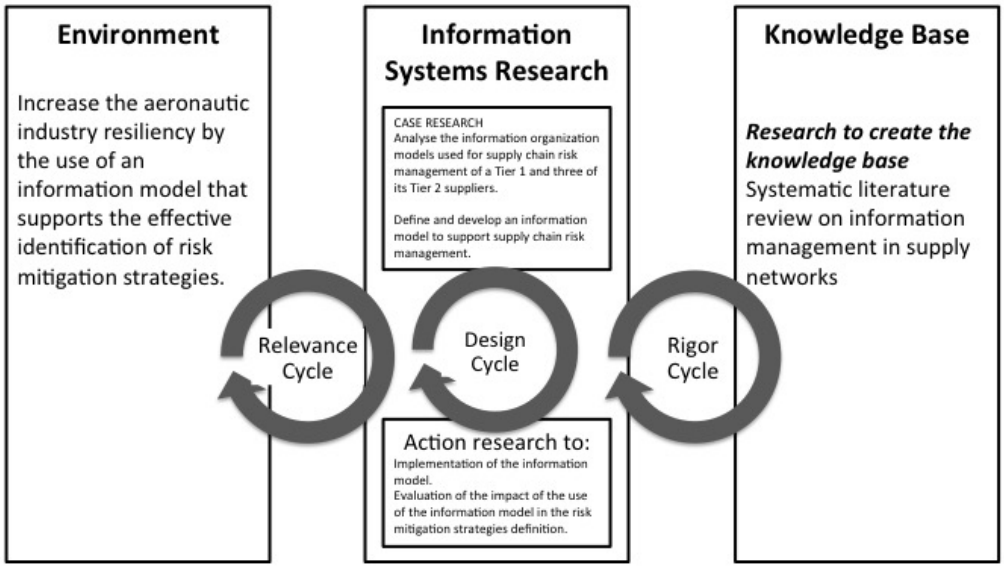

Figure 1: Design Science Research Framework.

Due to the exploratory nature of this research a portfolio of qualitative research methods is used: systematic literature review, field research and action research . Next, we briefly explain the application of each of these methods, and how they are embodied within the framework of Figure 1.

In the environment block we aim at identifying the needs of the aeronautic sector. Then, we adopt a systematic literature review to build the foundation of the knowledge base block. This research method is considered appropriate because it allows to identify the most relevant scientific contribution to a field or question, and ensures rigor of the review. The design science block uses case research to analyse the supply chain risk management process of a first-tier and three of its second-tiers in supply networks. Data collection will be carried out by means of semi-structured interviews at first-tier and three of its second-tier suppliers belonging to the network. All the interviews are recorded, transcribed and then coded with the support of specific software (MAXQDA).

Finally, the results from the systematic literature review and case research contribute for the design of an action research study. In particular, action research is adopted to implement and test an information

model for the evaluation of the impact of its use in the risk mitigation strategies of aeronautic supply networks. Action research is considered appropriate to investigate the development of solutions for actual problems where researchers and operations managers collaboratively contributed to the development of solutions.

3 The value to Society

The topic of information management in supply chains has been extensively studied in the past, though most researchers focus on the dyad OEM - first-tier supplier or the dyad first-tier - second-tier suppliers. The visibility model provides a way to increase awareness of supply network risks taking into account the different nodes' viewpoints.

Furthermore, this thesis contributes to literature and practice with a multi-view and aggregated model of internal and external information for decision support in supply networks in the aeronautic sector. The implementation and pilot use of this model in a real setting confirms the relevance of this work for practitioners and develop further managerial insights on the implementation of such models in practice.

Acknowledgements

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Comparing Robust and Stochastic Optimization for the Lot Sizing and Scheduling Problem under Uncertainty

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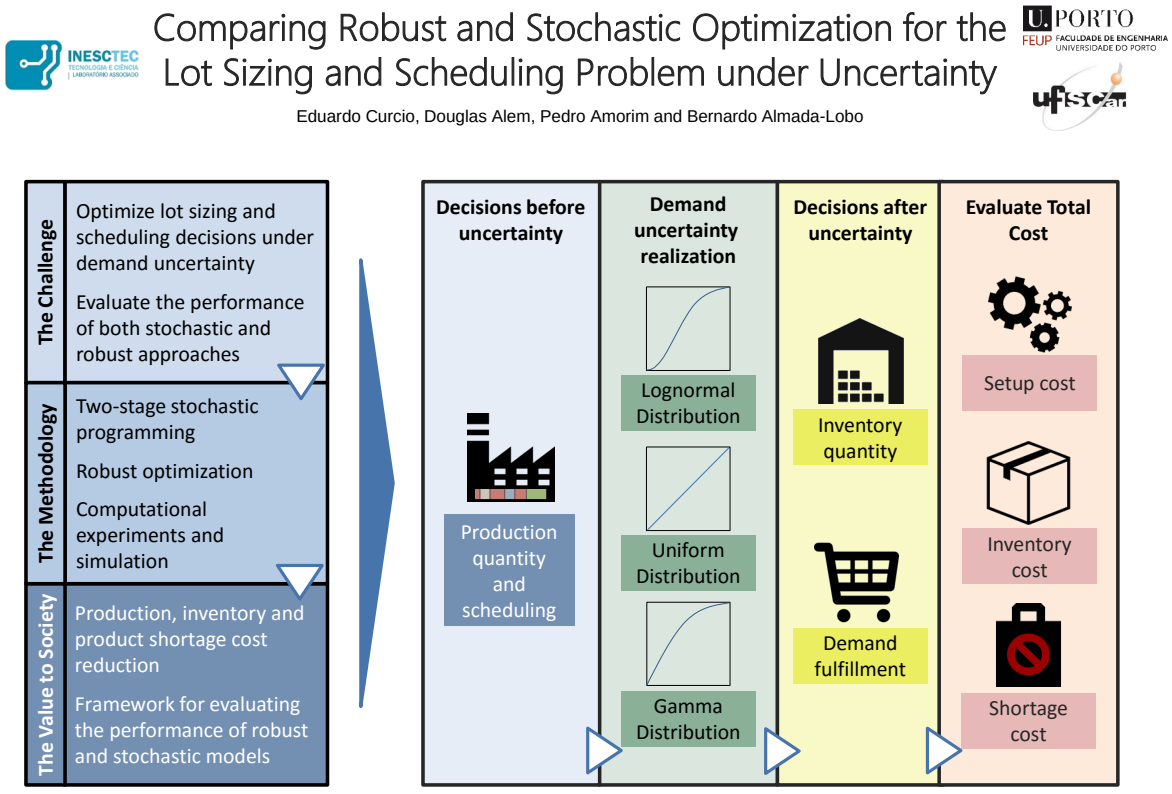

1 The Challenge

The development of mixed-integer programming models that integrate lot sizing and scheduling has drawn the attention of many researchers. Deterministic MIP models seem useful to address the integration of lot sizing and scheduling problems and many efforts have been undertaken in order to find both optimal lot size and production sequences. However, real world problems are subject to uncertainty that may occur in different supply chain stages, such as procurement, production and demand. For example, in settings in which demand is uncertain, deterministic models may not provide adequate solutions, leading to substantially higher costs associated to both product shortage and excess inventory.

Some authors address uncertainty in specific problems of production planning and scheduling using mainly stochastic programming. This approach has been useful in modeling it and providing solutions to some problems. On the other hand, stochastic programming is usually intractable and can demand a high computational effort, especially when there are a large number of scenarios. Moreover, it requires an assumption on the demand distribution in order to generate the scenarios.

Robust optimization is another promising approach that addresses the problem of uncertainty. This approach incorporates the stochastic character of demand in a deterministic manner without making any assumption on its distribution. Also, robust models are numerically tractable, however polyhedral uncertainty may lead to an excessively conservative formulation.

Although robust and stochastic approaches have addressed many uncertainty problems, there is a lack of experiments and research that assess and compare both methodologies. Moreover, these methodologies have several parameters that directly impact on their performance (e.g., level of robustness, budget of uncertainty and number of scenarios), making it more difficult to establish a fair comparison. The first challenge of this research is to develop robust and stochastic models that address uncertainty in the General Lot-sizing and Scheduling Problem (GLSP). The second one is the development of a framework that provides a fair comparison of both approaches and assesses the impact of their parameters on the solution quality in terms of average cost, cost distribution and robustness.

2 The Methodology

In this work, one robust and three stochastic General Lot-sizing and Scheduling models are developed in order to compare their performance when the demand is uncertain.

The stochastic models are modeled as two-stage programs and the scenarios represent the realization of the second-stage variables. Each scenario has a probability of occurrence, and the sum of all occurrences equal to 1. The first stochastic model is more conservative with a rigid production planning, where production quantity and production sequence are defined in the first-stage, before the demand is revealed, and in the second stage it is possible to decide the demand fulfillment.

In the second stochastic model, production sequences have to be defined before, and the decisions of production quantity and demand fulfillment are taken after the demand is revealed. Industries, such pulp and paper industry usually have the production sequence defined before the production lots, mainly because of the upstream process and the yield of the paper machine.

The third model incorporates a more traditional hierarchical planning process, in which lot sizes are defined in the first stage, and the scheduling of production and demand fulfillment are decided in the second stage.

The robust model is similar to the deterministic General Lot-sizing and Scheduling model, the only difference is that the model is adjusted to incorporate the uncertainty of the demand and the robust parameters. In the robust model, the decisions are taken all at once and it is possible to adjust some parameters that control the robustness level, such as the budget of uncertainty.

To compare the performance of the models a computational experiment simulates the demand and evaluate the costs. The experiment was carried out in the following way: after the model is solved, the first stage variables are fixed and a random demand is generated in order to simulate the cost. After a considerable number of demand realizations it is possible to estimate the performance of the cost of the models in terms of average, standard deviation, worst scenario and percentiles. Three different demand distribution patterns were analyzed in order to assess both robust and stochastic models: uniform, log-normal and gamma. We performed 1,000 realizations for each demand distribution in order to evaluate the stochastic models.

The impact of several parameters was tested for both approaches. For the stochastic model scenarios with 5 different number of scenarios were generated (100, 200, 300, 400 and 500) and with 3 different assumed demand distributions: uniform, gamma and log-normal (see Figure 1). For the robust model the budget of uncertainty (Γ^d_{jt}) was analyzed with 3 different values, varying with the time period, and $\hat{d}_{j\tau}$, that controls the robustness level, changing it from 0 to 3, increasing by a factor of 0.1 (see Figure 2).

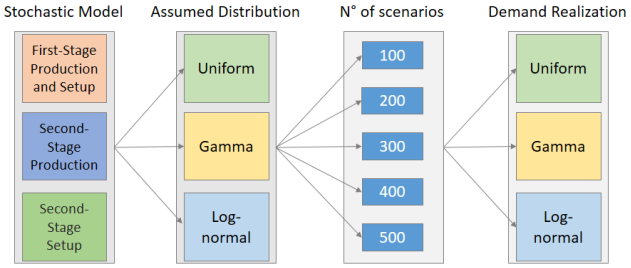

Figure 1: Simulation framework for the stochastic models.

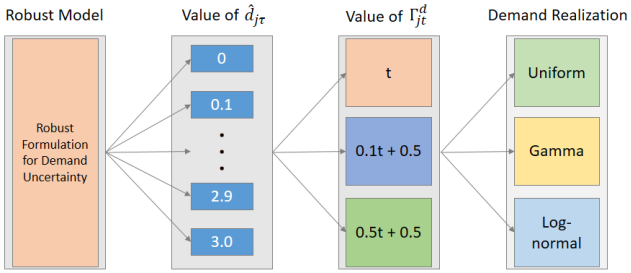

Figure 2: Simulation framework for the robust model.

3 The value to Society

The value to the scientific community of this research is twofold: the development of both robust and stochastic models to tackle demand uncertainty in General Lot-sizing and Scheduling Problem and the development of a computational experiment in order to compare the main advantages and drawbacks of both methodologies.

The robust and stochastic models aim to provide better solutions to the decision maker when demand is uncertain. It can lead to several practical benefits, such as reducing the total cost related to production, avoiding excess inventory and mitigating product shortage. These benefits are in line with the main challenges of many companies: reduce costs, increase productivity and competitiveness, become more sustainable and react quickly to customer uncertain demand.

Moreover, the experiment provides a study of the impact of several parameters, such as budget of uncertainty, level of robustness, number of scenarios and demand distribution assumed on the performance of both approaches. The theoretical benefit of this study is a better understanding of how these approaches can bring superior solutions, when demand is uncertain in GLSP.

Information management for collaborative decision-making in internationalization processes of SMEs

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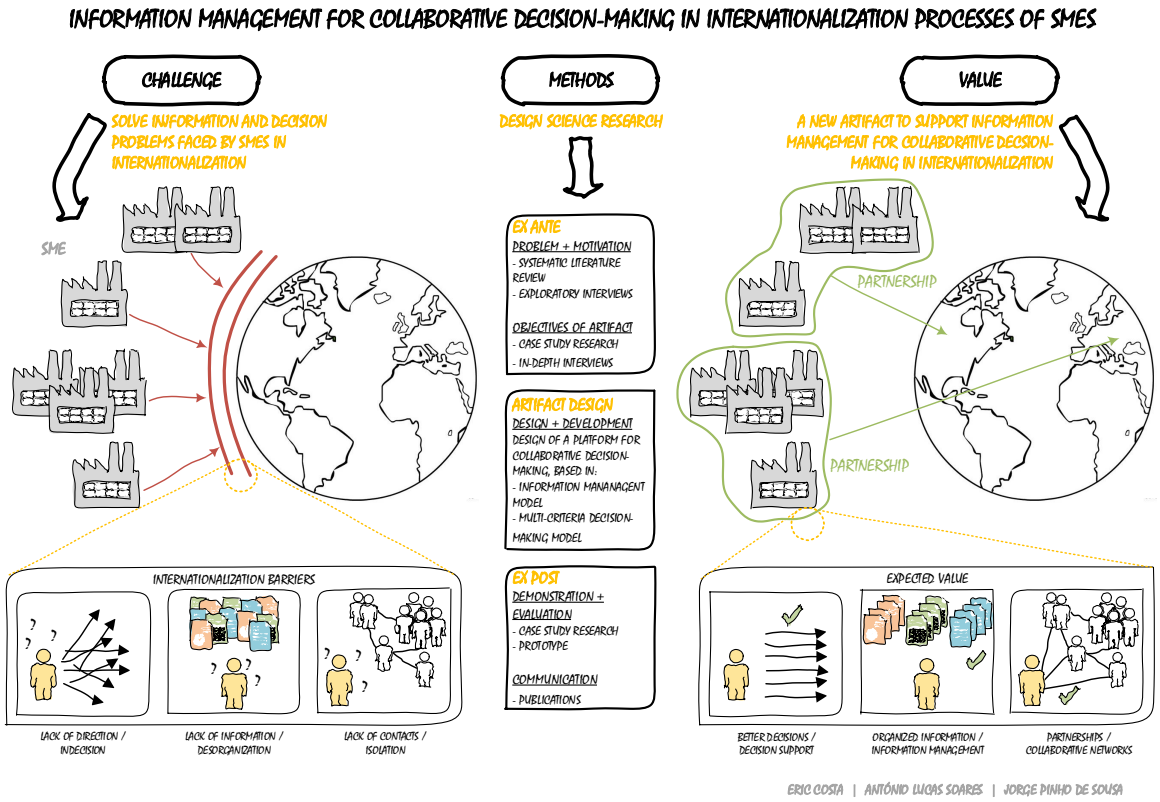

1 The Challenge

The world is becoming increasingly globalized and the international markets more and more open and accessible. The domestic saturation and the need to reduce competitive pressures leads companies to expand their businesses across borders, in order to increase sales and gain visibility in foreign markets. However, internationalization is a complex and hard process dealing with a large variety of decisions and, in most of the times, requiring a great amount of resources. Particularly in the case of small and medium enterprises (SMEs), standing out in this competitive environment is a difficult procedure, where the lack of information and the lack of contacts represent the main hindrances to internationalize.

In most parts of the world, SMEs are the backbone of the economy, contributing in a significant way for economic growth and development of countries. Nevertheless, many SMEs still face major challenges and internationalization barriers, i.e. they often do not know how to start an internationalization process, what are the decisions and entry modes involved, and which are the main types and sources of

information about foreign markets that enable more confident decision-making. In other cases, the lack of suitable tools, methods and practices for managing information and knowledge, both from previous international experiences and from partnerships with other firms, represents another problem for their internationalization processes.

To address this challenge, the motivation of the present work is to investigate how SMEs can access, organize and use information that is generated in a collaborative network context of internationalization, and also to understand how this information can be converted into valuable knowledge to support collaborative decision-making. The expected result is a design of a platform supporting collaborative decision-making based in a heterogeneous information management model allowing to combine formal, informal, internal and external information. The cases to be studied will be industrial enterprise associations (IEAs) and their respective SMEs.

2 The Methodology

This study will be conducted and its outcomes will be analyzed and validated following the Design Science Research (DSR) paradigm. The main goal of DSR is to create innovative artifacts, addressing unsolved problems in organizations, in order to contribute with new knowledge to the body of scientific evidence and to contribute to the real-world application environment. Therefore, following the DSR, an approach based on a complementary 3-cycle model will be used for this project (Figure 1): (1) relevance cycle, to bridge the contextual environment of the project with the design science activities; (2) rigor cycle, to connect the design science activities with the knowledge base (from scientific foundations, experience, and expertise) comprising the project; and (3) design cycle, to iterate between the core activities of developing and evaluating the design artifact of the project.

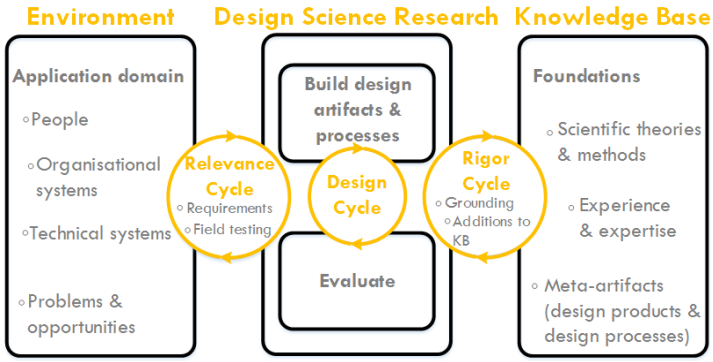

Figure 1: Design Science Research framework.

This project is then divided in three main stages: (i) ex-ante stage (define the problem and the motivation for the study, and the objectives of the artifact); (ii) artifact design stage (design and develop the artifact); (iii) ex-post stage (demonstrate and evaluate the artifact, and communicate the results). The central activity of this work is to design and develop an artifact addressing the challenge described in the previous section. In addition, two other important activities are the ex-ante and ex-post evaluations of the artifact. Some iterative process may occur during the course of this project, such as communication of some early results or iterations back to the definition of objectives and consequent new process of artifact design and development (to improve its effectiveness). Currently, this project is at the ex-ante stage, more precisely at the definition of the artifact to be developed.

Regarding the ex-ante stage of the project, the problem definition started with a systematic literature review (SLR), examining the role of information, knowledge and collaboration in internationalization decisions of SMEs. The main findings obtained with this SLR were: (i) there is no detailed systematic analysis on the specific content and subject of the information needed for making decisions in internationalization; (ii) there is a lack of comprehensive and systematic studies addressing how SMEs manage internationalization information generated in collaborative contexts; (iii) there is no evidence on how SMEs can convert information into knowledge to support decision-making in internationalization processes. After that, to better define the problem and the motivation of the study, exploratory interviews

to some IEAs will be performed. Using the results of the SLR and exploratory study, a case study research (CSR) will be then performed with two Portuguese IEAs, through a multiple embedded case study, to explore the information requirements of SMEs operating in different industrial sectors: i) the IT and electronics industry that operates in a quite uncertain context; and ii) the textile industry where more certain and foreseen environments are expected. The sources of evidence at this stage will be in-depth interviews to these two IEAs and to some of their respective associates, as well as documentation. To analyze the data, coding (using MAXQDA) and cross-case analysis will be done. This CSR will allow to define the objectives of the solution to be developed, as well as to perform a naturalistic ex-ante evaluation of the artifact.

In the second main stage of the project, it will be designed a platform for supporting collaborative decision-making in internationalization processes, which will be based in a heterogeneous information management model, as well as on some novel multi-criteria decision-making models. Following the DSR design cycle, the artifact development will occur together with the CSR and, at some points, data will be collected from the members of IEAs and SMEs that will be involved in discussing and giving feedback on intermediate concepts and prototypes of the platform. Finally, at the ex-post stage the artifact will be demonstrated and evaluated in some scenarios faced by SMEs, using again a CSR approach. Plans for the evolution and sustainability of the artifact will also be developed, as well as the communication of the scientific and technical results.

3 The value to Society

The main value of this study is to improve the internationalization processes of SMEs. The goal is to demonstrate that using the developed artifact, IEAs can intervene more actively in the internationalization of their associates and SMEs can improve their decision-making capacity to internationalize.

The information management model will allow to search, collect, integrate, organize and visualize internationalization information, from different internet accessible, heterogeneous public and private sources (e.g. export assistance, export intelligence, international marketing research or the Internet), to be used and adapted in different contexts where SMEs are embedded (such as industry type context, institutional context, decision mode context, internationalization strategy context). The decision support system will allow SMEs to select markets and entry modes, as well as to choose partners.

In terms of contributions to the scientific knowledge, the project will contribute mainly to the research areas of international business (IB) and information management (IM): (i) by addressing important research problems and opportunities regarding internationalization decisions of SMEs; and (ii) by developing a new artifact to support information management for collaborative decision-making in internationalization processes.

Acknowledgments

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Tackling a large real-world production-routing problem in the meat stores of a hypermarket chain

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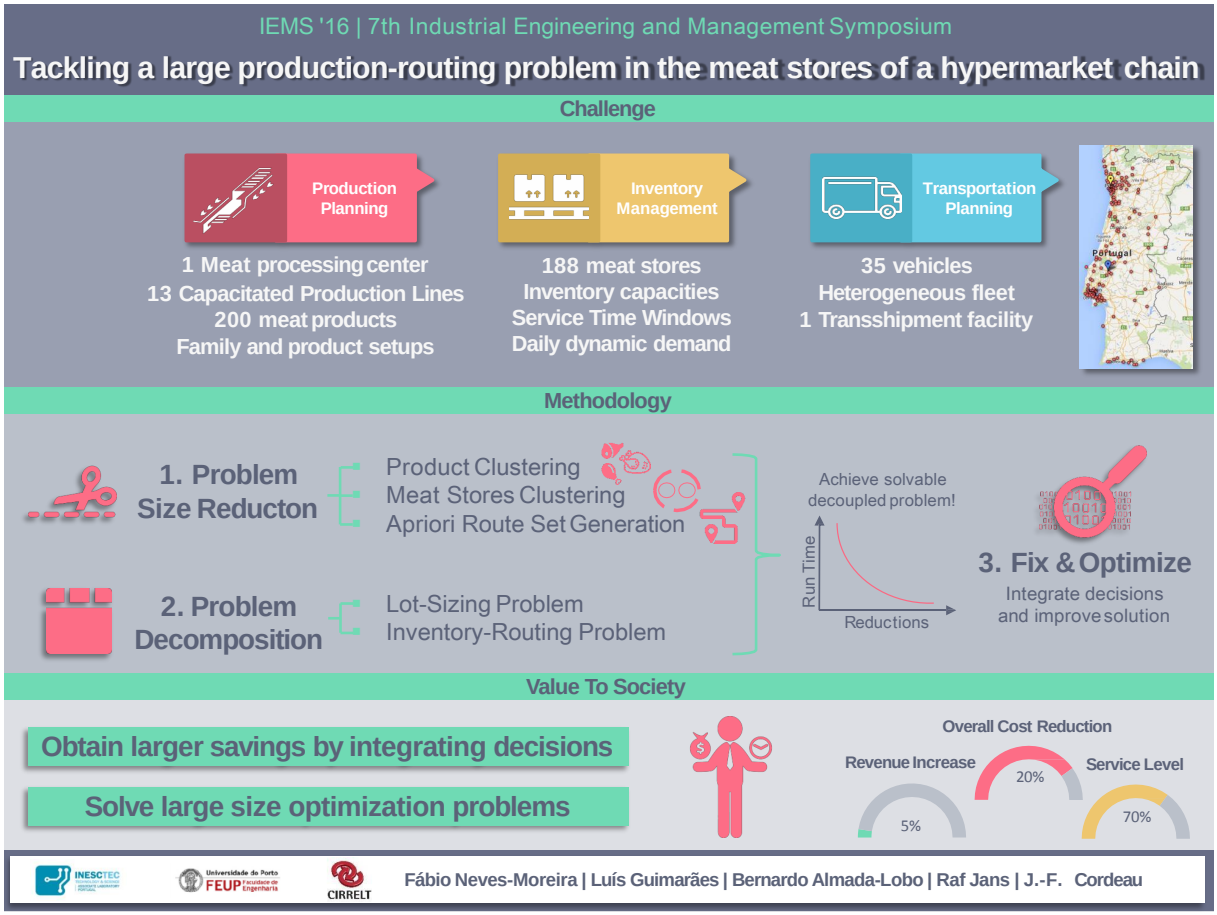

1 The Challenge

The Production-Routing Problem (PRP), which integrates production, inventory and distribution decisions, is amongst the most demanding and critical challenges in operations management. The joint optimization of sequential activities in supply chains has been proved to achieve large cost savings when applied to simple real-world contexts. However, the literature is scant when the processes to be described by the mathematical models need to include the complex features of real problems. The challenge to be tackled in this work is an integrated planning problem inspired by the case of a Portuguese hypermarket chain which applies a Vendor-Managed Inventory (VMI) policy to its meat stores. Figure 1 provides an overview of the challenge (each number is described below).

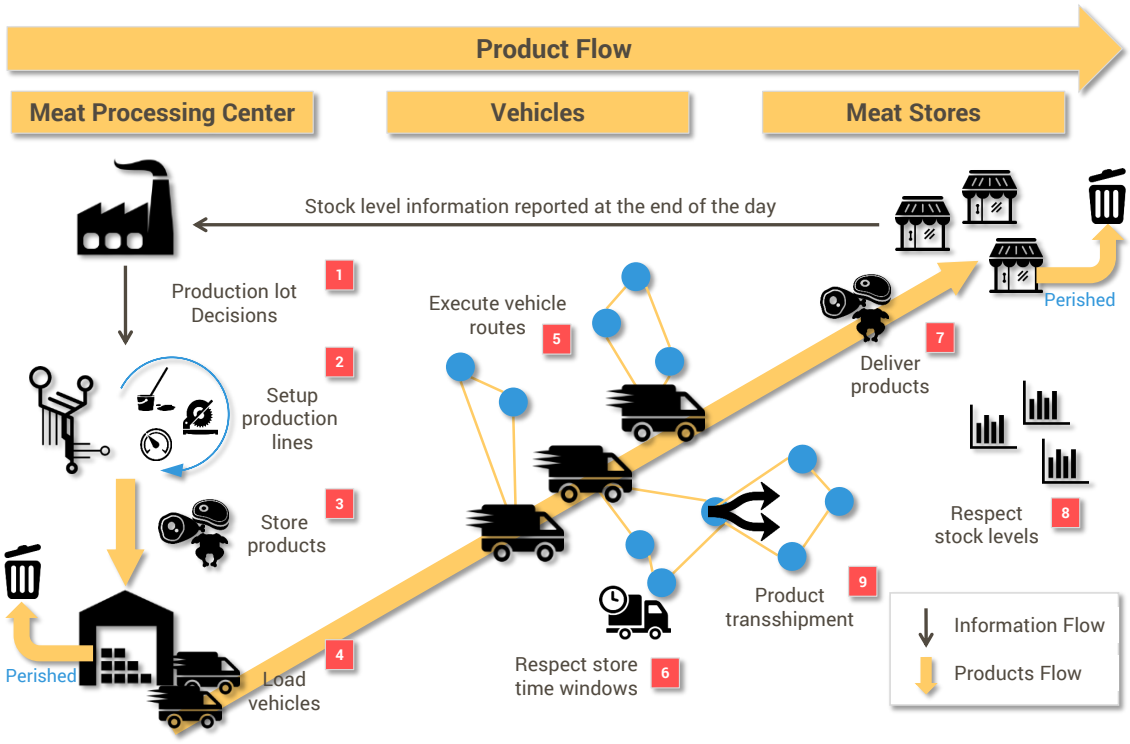

Figure 1: Overview of the PRP to be solved.

The company manages a single meat processing center in the south part of the country, where several distinct production lines are able to produce different sets of product families composed by several products. Therefore, in order to produce a certain mix of products, different production line setups may be needed, which, if not carefully planned, may result in substantial time capacity losses (1,2).

After being processed and packed, the products may be stocked (3) or loaded into the vehicles (4) to be delivered. The company owns and manages an heterogeneous fleet of vehicles and decides the delivery routes to be performed by each vehicle. Each driver performs a different vehicle route (5) in order to deliver the necessary products and quantities to satisfy the demands of each meat store. Note that in this realistic context, each meat store may only receive deliveries during a certain time window (6). Furthermore, the delivery quantities (7) have to respect the capacity of the warehouse of each meat store (8). Since all the vehicle routes need to depart and return to the depot, it would be impossible to perform all the deliveries in the north of the country, given that the legislation prohibits drivers to work more than 9 hours a day. Therefore, deliveries are also made to a transshipment facility located in the northern part of the country which has a smaller fleet. A larger vehicle delivers the products to be distributed by the fleet based at the transshipment facility (9). In the meat stores, the customer demands need to be satisfied on a daily basis. Products may perish either at the warehouse of the meat processing center or at the meat stores, in case they are not sold to the final customer before their expiration date. Therefore, perishability also needs to be taken into account.

Given the complexity of the problem, it is extremely difficult to obtain integrated solutions manually. The operation is still based on decoupled production and transportation plans, despite the promissing gains offered by integrated planning. Our objective is to solve the integrated problem and quantify the potencial gains of such approach.

2 The Methodology

Given the size and complexity of the integrated PRP we aim to tackle, it is unrealistic to develop a monolithic solution method that takes into account the entire solution space. Therefore, we propose several techniques for reducing the problem size, while maintaining the objective of providing good

feasible solutions for the entire real-world problem. The size-reduction techniques allow to pre-process the data of the problem and focus on three different aspects of the problem: number of stores, number os products, and number of possible routes.

Firstly, stores are clustered based on historical data of deliveries. In case two stores are frequently visited at the same day and time, it makes sense to cluster them and serve the by the same route.

Secondly, after clustering the stores, we build a set of potential routes. Again, since the company already has a historical base of routes, we analyse them and detect characteristics to be incorporated in the generated routes, for instance, the maximum number of visited stores per route. New routes can be created using a simple cheapest insertion algorithm.

Thirdly, we also propose to reduce the number of products to be considered by clustering less important products, considering sales volume. Here, an ABC analysis is performed and the C products are clustered by family (as family changes have higher impact on the production part). Since these products's sales are small and thus difficult to forecast, we consider that a smaller priority can be given to them during the planning phase. Note that with this procedure we can reduce the number of products up to 80% (according to the Pareto Principle, A and B products are still kept disaggregated).

After this pre-processing phase, we follow a decomposition approach to generate an initial solution. Two separate mathematical models are used. The first deals with the production part and the second is designed to solve the remaining Inventory-Routing Problem (IRP). To improve this initial solution, we integrate the two solutions in a single monolithic model which is solved via a fix-and-optimize algorithm.

The developed approach is to be validated within the real context of the company, in order to assess its value against decoupled production-distribution plans.

3 The value to Society

The integration of different planning problems is the next step in order to achieve larger gains using operations research. Indeed, when a company decides to integrate its planning processes, alone or co-operatively, there is not only a direct benefit for the company itself but also plenty of indirect benefits that are absorbed by the surrounding entities. Particularly with the PRP, companies are able to reduce production, inventory and transportation costs while increasing their service level. From the perspective of the consumer, products are available at the right quantity and at the right time, meaning that several sources of waste are largely reduced as resources are allocated more rationally. The models developed in this work can be applied to a wide variety of process industries such as oil products, food, electrical components, vending machines, and apparel. Regarding our methodology, by reducing the size of the problems by incorporating historical data provided by the companies, we are allowing the possibility to solve larger and more complex problems, maintaining the objective of obtaining good quality solutions, applicable to the real-world. Note that this is true not only for the PRP but also for other general optimization problems of large dimension.

Supply Chain Risk Rating: An assessment framework based on Continuity and Complexity

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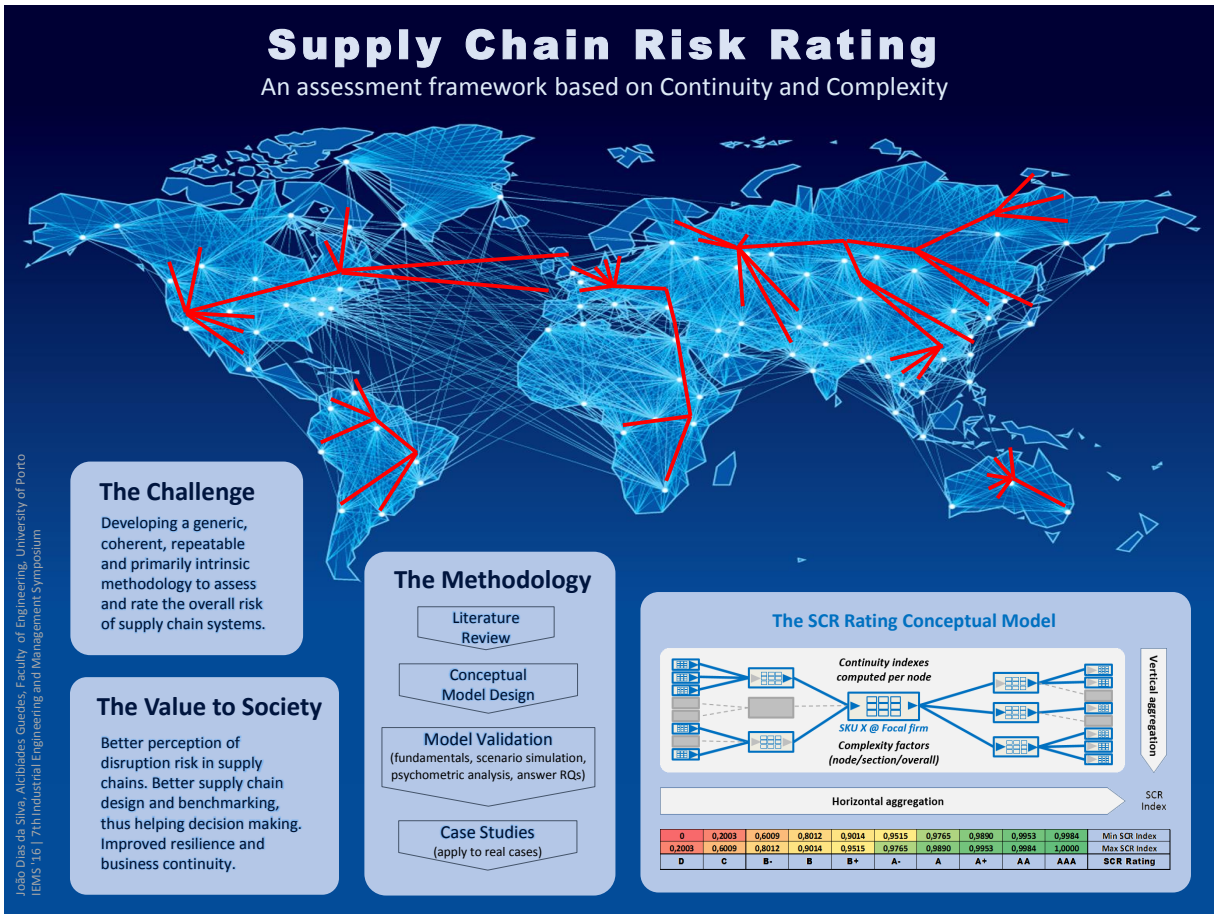


1 The Challenge

The World lives today an unprecedented era of uncertainty, in which governments, organisations and society at large are continually challenged to cope with new forms of disruptive events and conditions, such as those resulting from terrorism, geopolitical issues or natural disasters. At the same time, some established paradigms, such as globalisation or the increasing dependency of our lives on information and technology resources, bring on new sorts of uncertainty, alongside increased volatility, complexity and ambiguity. Within this environment, the design of resilient supply chains has become of the utmost importance, and so has the need for innovative methods and tools that can assist in measuring and monitoring the risk level in supply chain systems.

Supply chain risk management is typically based on standard cyclic risk management frameworks, which are composed of risk "identification, analysis, evaluation and treatment". While these frameworks are

generally well suited to address specific supply chain risks in ongoing operations, the demand for an integrated end-to-end perspective about risk in supply chain systems (from upstream to downstream, from design to implementation) has become more and more popular, thus driving the need for assessment tools that are able to consistently synthesise and rate the overall risk of supply chain disruption. This "aggregate" approach has been extensively addressed and advocated by "enterprise risk management" models, and its importance and usefulness for managers have been confirmed by several behavioural risk analysis studies. Therefore, the following research questions have been formulated: (RQ1) *Which common criteria and modelling procedures should be used to assess risk in the supply chain, so as to ensure consistency among different supply chain sections and aggregation levels, and throughout time?*, and (RQ2) *What are the requirements and what is the most appropriate methodology to rate the overall risk level of supply chain systems, regardless of industry and market characteristics?*

2 The Methodology

This research project is essentially exploratory and its goal is to create an innovative and effective framework to assess and rate overall supply chain disruption risk. The research methodology is summarised in Figure 1 and includes: (i) a thorough literature review of risk management theory and pratice, supply chain risk (SCR) assessment frameworks, and rating methodologies, (ii) the development of an original conceptual model for SCR Rating, (iii) the formal validation of the model, regarding its fundamentals and some relevant psychometric attributes (through mass supply chain scenario simulation), and (iv) the application of the model to real cases.

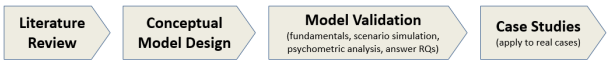


Figure 1: The research methodology.

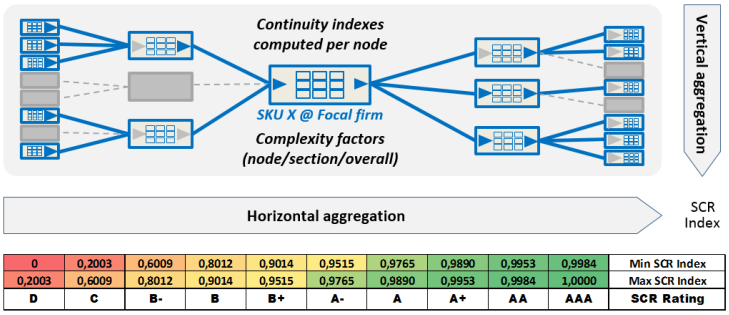
Our ultimate goal is to create a generic, coherent, repeatable and primarily intrinsic SCR Rating method. By *generic* it is meant that the proposed framework is supposed to be applicable to a wide range of supply chain systems, regardless of industry, size or configuration. By *coherent*, it is meant that the proposed rating is expected to be consistently computed for broader and shorter extensions, as well as for more or less aggregated levels of supply chain systems. By *repeatable* we mean that the proposed rating methodology should be stable and consistent throughout time, allowing current output to be compared with future results. Finally, by *primarily intrinsic* we mean that the proposed methodology should be fundamentally based on observed features and objective measures obtained from within the system, rather than on perceptions, estimates or any other subjective measures.

No matter how thoroughly most corporations are able to identify, assess and treat their main risks, they will usually fail to foresee some relevant type of risky event or circumstance, and/or will often be surprised by the actual frequency or disruptive power of some known risks. The emergence of "security management systems" and "business continuity management systems" sends us a clear signal about the need to improve preparedness to cope with unpredicted or unknown conditions. Following this logic, instead of putting most efforts into the assessment of all plausible risk sources for a supply chain system (which is obviously a useful exercise), our main focus is rather on the system resources and processes, and on the potential disruptions that may affect operational flows (physical, informational or transactional). *How well is the supply chain system prepared to cope with disruptions, whatever causes them?* Our rating should be able to give a satisfactory answer to this question.

For each SKU (finished product) located at a focal firm, the supply chain is modelled as a process network that emerges upstream, according to the *bill of materials* structure, and downstream, through the distribution channels (see Figure 2). Each node/process corresponds to a certain location (production or storage facility) and potentially entails inbound/outbound transport sub-processes. Complex processes may be split into two or more nodes/sub-processes at the same location. A simplified "business impact analysis" procedure is conducted at each node/process, in order to determine the preparedness status (prepared vs. not prepared) at that location, with regard to a list of applicable resources (e.g. people/labour, facilities, equipment/machinery, vehicles and transport routes, utilities, etc.). The "Continuity index" is computed at each node of the network, as a decimal number between 0 and 1, and then aggregated within the same section/stage of the supply chain (i.e. vertically) and across the various

sections/stages of the supply chain (i.e. horizontally). *Vertical aggregation* is computed through weighted averages (according to business volumes) and always precedes *Horizontal aggregation*, which is computed through quadratic means. These aggregation procedures also employ a number of "Complexity factors" derived from observed features and contextual conditions at node, section and overall levels (e.g. volume concentration, network configuration, network length, process ownership profile, "Logistics Performance Index" by the World Bank, "World Risk Report" indexes by the UNU-EHS, etc.).

By definition, an overall "SCR Index" results from a full vertical and horizontal aggregation process, be it for a single SKU, or for a group of SKUs (ultimately, for a full business unit, or a even a full business corporation). The "SCR Index" is a decimal number between 0 and 1, and the corresponding "SCR Rating" is determined within a 10-level scale (based on exponentially increasing/decreasing numeric ranges), where "D" corresponds to the worst performance and highest disruption risk, and "AAA" corresponds to the best performance and lowest disruption risk.



0	0,2003	0,6009	0,8012	0,9014	0,9515	0,9765	0,9890	0,9953	0,9984	Min SCR Index
0,2003	0,6009	0,8012	0,9014	0,9515	0,9765	0,9890	0,9953	0,9984	1,0000	Max SCR Index
D	C	B-	B	B+	A-	A	A+	AA	AAA	SCR Rating

Figure 2: Determining the SCR Rating for 'SKU X'.

The validation of this construct requires: (i) a large scale simulation of supply chain scenarios, (ii) the computation of the "SCR Index" (and "SCR Rating") for each of them, and (iii) an integrated analysis of the results, regarding a number psychometric attributes, namely *acceptability*, *internal consistency*, *validity* and *responsiveness/sensitivity*. The construct must also be applied to some real cases (supply chains of different sizes and industries), which will certainly provide important inputs regarding its suitability and usefulness in real environments (interpretation and meaningfulness, ease of computation, potential for automation, other opportunities for improvement, etc.).

3 The Value to Society

In recent years, the World Economic Forum has consistently produced the annual Global Risk Reports and has classified "Resilience as a 21st Century Imperative". In January 2015, the International Standardisation Organisation (ISO) established a new Technical Committee ISO/TC 292 on the field of "Security and Resilience", which is now in charge of important standards such as the ISO 22301 ("Business Continuity Management Systems"), the ISO 22316 ("Organisational Resilience", still under development) or the ISO 28000 series ("Supply Chain Security Systems"). These developments clearly show the importance and currency of the proposed topic and, in a certain sense, help validate/justify the approach, which is based on continuity and complexity.

As previously discussed, the overall assessment of Supply Chain Risk (SCR) tends to be an increasingly relevant topic, not only as a complement to standard risk management implementations, but also due to its role in strategic management activities such as "supply chain design" and "internal/external network benchmarking". Moreover, the use of standardised methodologies and measures in SCR assessment has obvious practical advantages, both for individual firms, and for the markets in general. Future research may also include longitudinal studies of "SCR Rating" trends within firms, industries and markets, or the refinement of the methodology to address specific business model traits (e.g. service-oriented, e-business, etc.).

The ultimate goal of this project is to build a better perception of disruption risk in supply chains, thus helping strategic, tactical and operational decisions, adding transparency and reliability to processes, improving business continuity and fostering value creation.

Alignment process in the implementation of a health screening program

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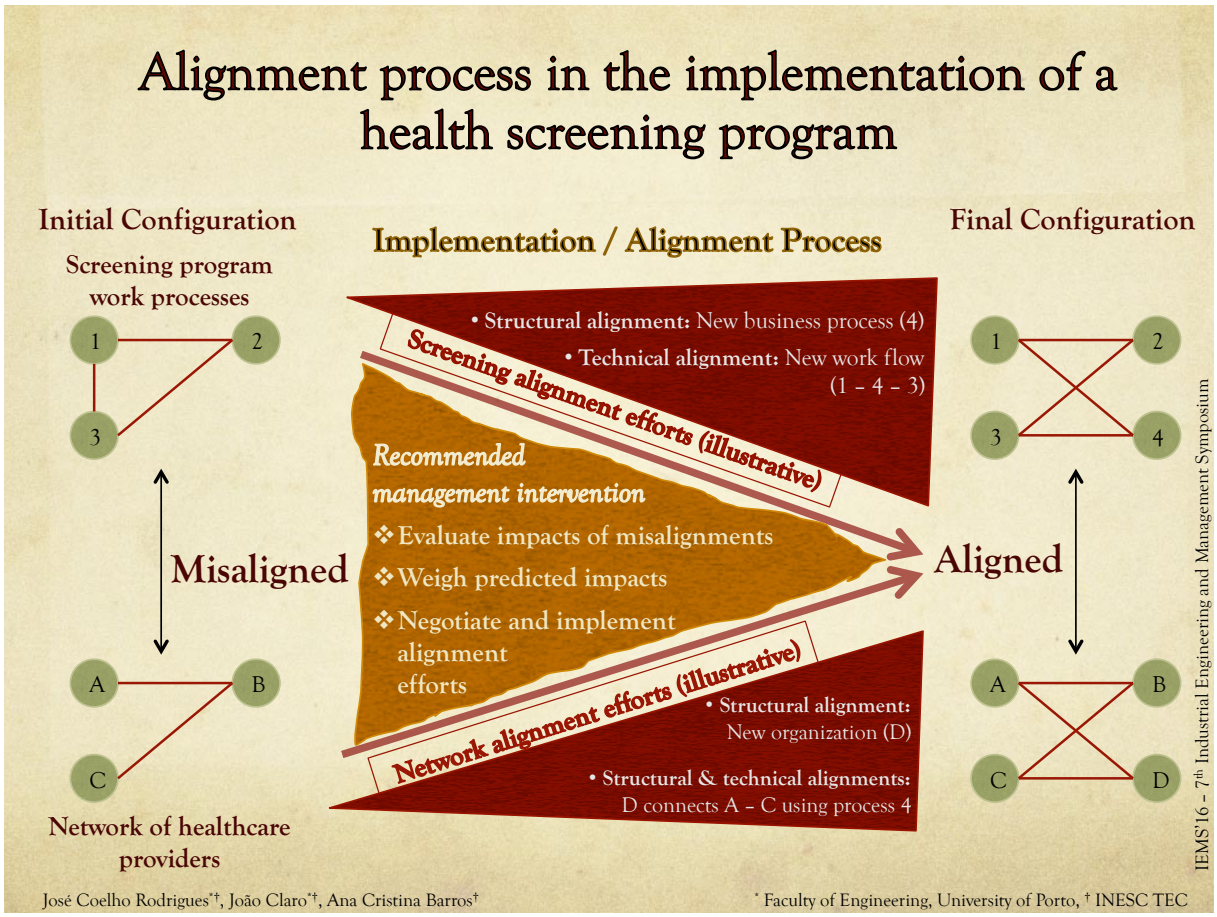

1 The Challenge

Implementations of technological innovations have been conceptualized as sequences of alignment for a few decades. Such implementations face initial losses of productivity mainly due to misalignments between the technology and its adopter, which usually lead to a dynamic sequence of mutual adaptation efforts between their structures and capabilities. Mutual adaptations, or sequences of alignments, are thus an important challenge during implementation management.

Networks of organizations are particularly challenging settings for implementation of technologies, due to the need to orchestrate decisions between multiple organizations and to the fact that network evolution dynamics depend not only on the individual organizations, but also on their mutual alignment. Technological solutions are important for the operations of the network, in particular because they support the interactions between its organizations. The full realization of the potential of technological innovations requires a good understanding of their implementation processes, which are critical for the assimilation of

the technology in the routine operations of the adopter. In the context of implementations of innovations, misalignments between a technology and the network of organizations adopting it result from a lack of compatibility between both. Accordingly, alignment can be achieved through an alignment process, i.e. changing the technology and the network with the objective to increase the compatibility between both. Those alignment efforts are expected to require structural, technical or capacity adaptations of both the network and the technology.

The alignment process is a complex, sequential and evolutionary process that results from interactions between different categories of alignment, suggesting that those efforts occur as non-linear and cascading sequences of alignments. Non-linearity refers to the interactions between different categories of alignment during the sequence of alignments. Such non-linear sequences are important mechanisms to be considered during implementations since some dimensions of the network or of the technology may be difficult to change, but may be easily influenced by changes in other dimensions. For example, a capacity misalignment observed in one organization of the network may be difficult to overcome, because there is no possibility of 'hiring" more resources, but it may be overcome by a technical alignment of the business process. Cascading sequences of alignment also emerge as important mechanisms throughout the implementation process since some alignment efforts implemented to overcome one previous misalignment may create new misalignments that require the implementation of further alignment efforts. Consequently, non-linear and cascading sequences of alignment may provide interesting findings to contribute to knowledge concerning implementation management, namely the management of sequences of alignment.

Research on sequences of alignments during implementations of technologies in networks has been scarce and motivates our research. Nevertheless, it was found to be sufficient and significantly spread throughout different disciplines to justify a literature review. As a review on this topic could not be found in the literature, a systematic review was conducted providing a thorough aggregation of the findings up to this date. The main goals of the review were to understand what is known in the management research literature about: (a) the efforts to align innovation and its adopters during the implementation of the technologies in networks and (b) about management interventions associated with dealing and controlling the sequences of alignment.

Furthermore, based on the results of that literature review, non-linear and cascading sequences of alignment were examined using an inductive multiple case study about implementations of a health screening program in several networks of healthcare providers located in the North of Portugal. The purpose of the multiple cases was to understand how do non-linear and cascading sequences of alignment between a technology and a network arise during implementation projects, what are the consequences of non-linear and cascading sequences of alignment in the implementation process, and how are non-linear and cascading sequences of alignment managed during implementations.

2 The Methodology

With the objective of synthesizing the current knowledge about how to manage the alignment between a technology and its adopter during implementations in networks of organizations, a systematic literature review (SLR) was conducted. The SLR is a replicable, systemic, scientific and transparent method to address a specific question that minimizes bias through exhaustive literature searches and by providing a detailed description of the processes of reviewers decisions, procedures and conclusions.

To explore the non-linear and cascading sequences of alignment, a multiple case study of implementations of the diabetic retinopathy screening program in the North of Portugal was conducted. It followed an inductive research design, using embedded multiple case studies, where the unit of analysis was the implementation project in each network of healthcare providers. As case studies allow rich, in depth empirical descriptions, and are based on a variety of data sources, they were found to provide a suitable research design for examining and clarifying the type of complex processes that are face in this research – implementation processes involving a large number of critical actors and factors.

Eight cases were selected using a theoretical sampling strategy, allowing for theoretical replication logic, which ensured external validity and helped guard against observer bias. The sample was large enough to reach theoretical saturation and increase confidence in the results. The research strategy involved semi-

structured interviews as primary sources of data, and collection of archival documents and statistical data concerning the outcomes of the implementation to provide credibility and strengthen results by triangulating the sources of evidence. Data was explored iteratively, going back and forth the qualitative data and theoretical arguments. The analysis was divided in two stages: (1) within case analysis, selecting and organizing the relevant data and searching for within case patterns, and (2) cross-case analysis, searching for cross-case patterns. From those, analysis propositions and practical recommendations were developed.

3 The Value to Society

The findings from the literature review cover alignment issues faced during the adoption decision and the implementation of the innovation, as well as the impact of the alignment efforts in the implementation outcome. Even though there is still much to be explored, since this is a relatively new topic and research is still limited (only 41 papers were found to have contributions to this topic), it was already possible to draw a conceptual framework that can guide future research and management of implementations of technologies in inter-organizational networks. Therefore, a conceptual framework is proposed, which consolidates the findings from the literature and is believed to be a valuable systematic summary about what has been studied so far concerning this topic, as well as a relevant tool for future research and management action.

The findings from the multiple case studies contribute to the technology management research community by providing evidence that increases the understanding of sequences of alignment, namely non-linear and cascading sequences, which appear to be important mechanisms throughout the implementation process in networks of organizations. Additionally, practical managerial and technological recommendations are provided and typical behaviours are outlined concerning the two same phenomena. To provide an example, the most general management recommendation concerns the preparation of implementing an alignment effort, where implementation managers shall:

1. Carefully evaluate the complete impact of the alignment effort and the misalignment intended to be solved in the network and in the implementation outcome (namely its objectives).
2. Map and divide the predicted impacts of the alignment effort on different organizations of the network and on different outcome measures of the implementation to simplify further analysis.
3. Assign weights to each impact, reflecting their importance to the implementation project and to the network.
4. Finally, based on the previous analysis, promote the negotiation of the alignment effort implementation between the different members of the network.

Performance Improvement Indicators for the Third Mission of Brazilian Universities

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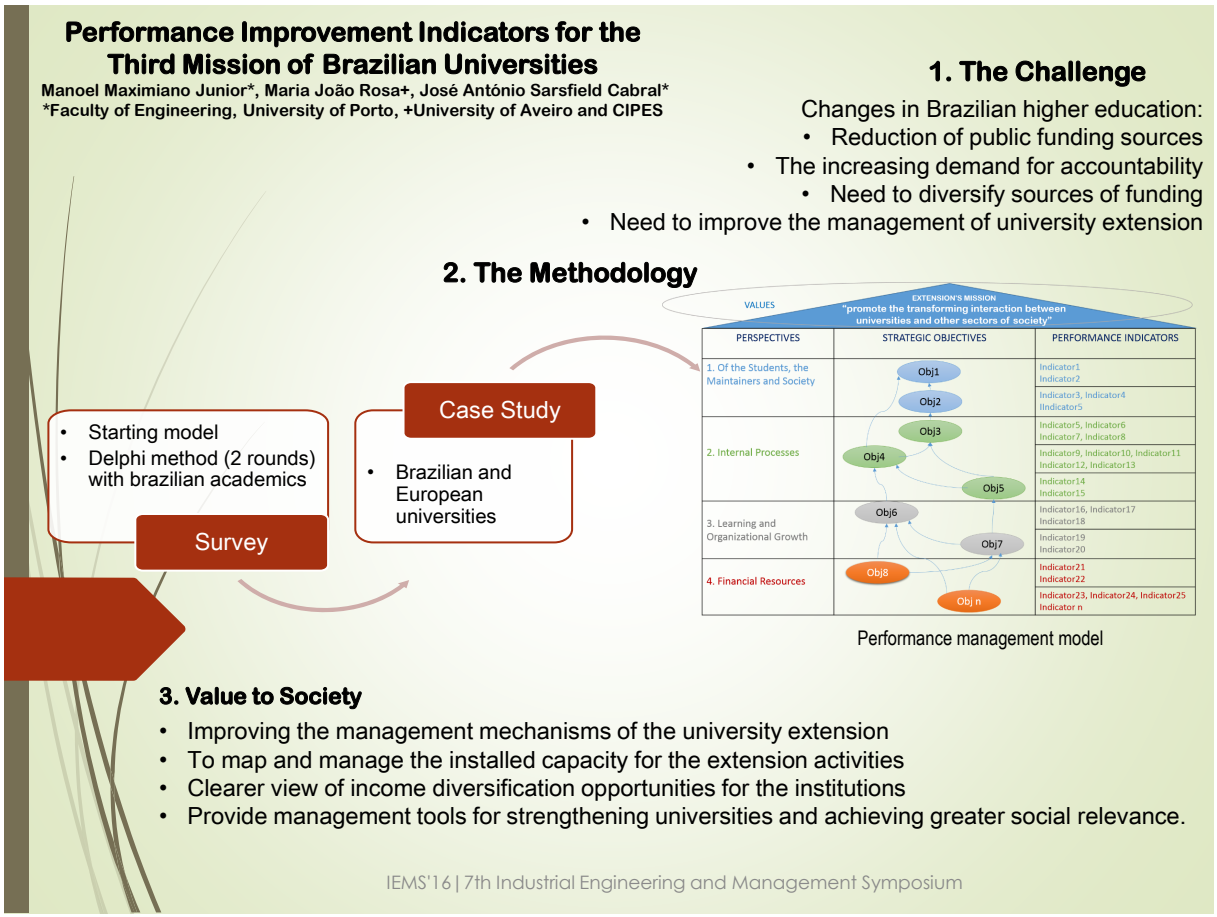


1 The Challenge

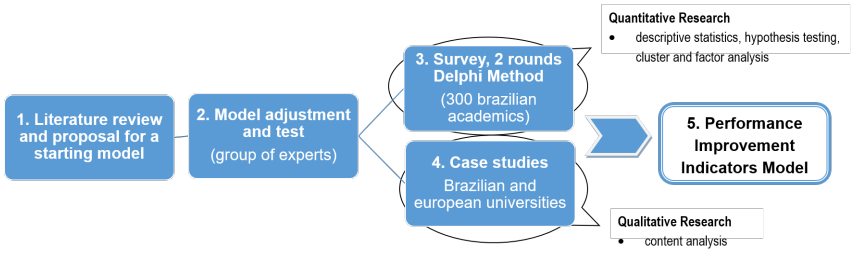
The development of mechanisms for performance evaluation in public universities is a growing field of interest in Brazil and other countries. These performance evaluations are mainly driven by the following factors: reduction of public funding sources, the need to improve the management with relatively diminishing resources, the increasing demand for accountability from the different stakeholders and the strengthening of the competitive culture, present in public notices and in institutional ranking initiatives from the performance. Regarding the three operational areas of universities in Brazil, i.e. teaching, research and extension, the latter is the one where least progress has been made in terms of assessment tools and control of activities. In Europe, the most widespread correlate term to university extension is "Third Mission". This received increasing attention from the academic community, and also was funded by the European Community (2009-2012), through the E3M Project - European Indicators and Ranking Methodology for University Third Mission involving 8 institutions from 7 countries, among other examples.

In Brazil, there is large gap of studies on the management of university extension with the use of indicators. The only prominent noteworthy work is from the Pro-Rectors Forum Extension of Public Institutions of Higher Brazilian Education (FORPROEX), which is an entity dedicated to the joint definition and extension policies that currently brings together about 120 federal, state and municipal institutions. In the private academic sector, almost nothing has been produced, and these institutions usually adopt the models adapted from public institutions. With this on focus, we can see a lack of discussion and management models with propositions sustained in feasible indicators that can be adopted to improve the performance of universities in the extension area. Lack evaluation and control instruments able to support a capacity building policy-oriented outcomes that can be quantified. Based on these findings, this research aims to propose a model of indicators for strategic management of the third mission of Brazilian universities, based on the evaluation of the conceptual perception of a representative group of academic country staff, current indicators used and European models of reference.

2 The Methodology

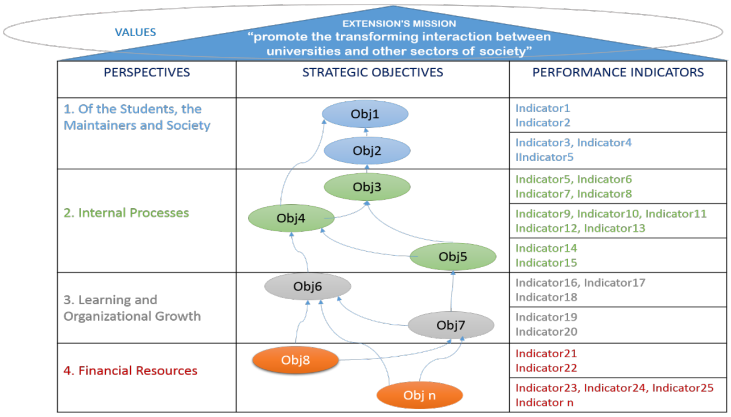
The theoretical design of this study proposes a model composed by the following features: 1) Concepts, policies and proposals on University Extension; 2) Analysis of European valuation models for the third mission; 3) Guidelines of the Ministry of Planning, Budget and Management of Brazil (MOP); 4) Performance measurement and management methodology of the Balanced Scorecard (BSC).

The research is being developed in accordance with the following flowchart (Figure 1):



This research is supported by the FORPROEX, which indicated a group of specialists with 6 pro-rectors of university extension of four different regions of Brazil, to support the development of the work. Last November (5th), during the 38th national meeting of FORPROEX, this research project was presented to a group of 144 academics from all over Brazil (most pro-rectors extension) getting the commitment to participate in the survey. Currently research is in phase 2. Oriented towards achieving the mission of the university extension which is "to promote the transforming interaction between the University and other sectors of society" (FORPROEX), have been proposed and are being tested 15 strategic objectives and 58 indicators. These were initially framed in five dimensions of the extension evaluation, such as follows: Management Policy (15), Infrastructure (10), Academic Plan (11) Relationship University-Society (13), and Academic Production (9). After 2 rounds, we expect to reduce to 60% the number of indicators used. The same indicators will be analyzed according to the MOP process view in order to classify them as follows: Input indicators (24), measure installed capacity; Process-Product indicators (18), measure productivity and efficiency in course; Outcome indicators (16), measure quality and effectiveness. Finally, the objectives and indicators will be aligned in the BSC framework considering four perspectives defined from the literature review, strategic objectives and indicators tested, the outgoing model follows the vision bellow (Figure 2).

The calculation of the indicators of feasibility analysis and applicability of the model will be assessed in the case studies.



3 Value to Society

Considering the importance of universities to economic and social development of countries, the proposal of a model of management of his third mission based on performance indicators can generate a number of direct contributions, such as improving the management mechanisms of the third mission activities and strengthen their strategic importance in the institutions; another contribution is to map and manage the installed capacity in the institutions to offer different types of programs and services based on indicators and targets. The last contribution is to allow a clearer view of income diversification opportunities for the institutions. As a result of greater effectiveness in managing their third mission and expected institutional strengthening universities will increase the supply of stocks, products and services of value to society as well as to prepare students with skills and civic values.

Effective design of backroom storage in retail food stores

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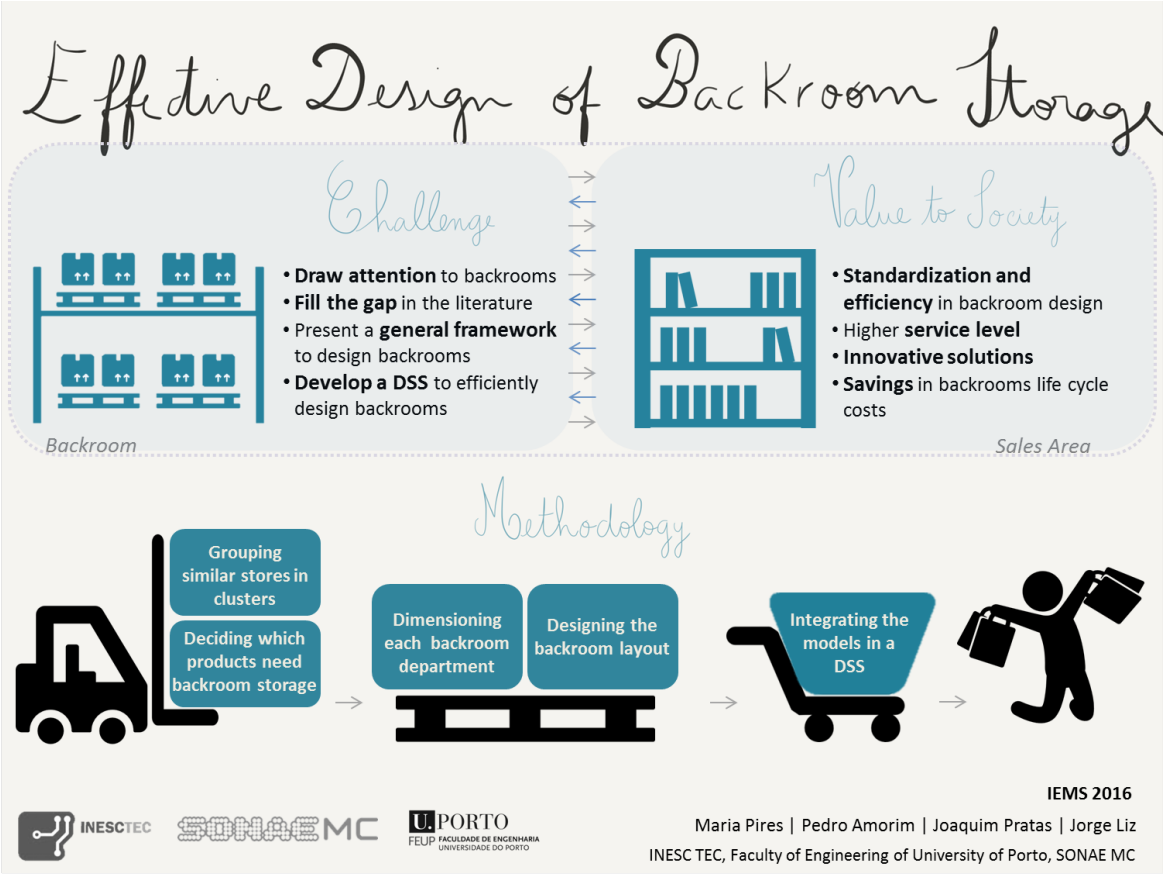

1 The Challenge

The design of retail backroom storage is a strategic decision that has a great impact on in-store operations, customer service level and store life-cycle costs. Moreover, backroom storage in modern retail grocery stores is crucial to several functions, such as acting as a buffer against strong demand lifts yielded by an ever increasing promotional activity, stocking seasonal peak demand, and accommodating e-commerce activities. Despite having similar functions to conventional warehouses and distribution centers, backroom storage facilities have particularities that deserve a distinct analysis. For instance, these facilities have to coexist with the sales area, which competes for the same space and resources. Furthermore, they need to account for the shelf replenishment process and to store products at different temperatures. The challenge of this overall problem is to address the following three objectives:

- Firstly, we aim to draw attention to backrooms, emphasizing their importance in the supply chain, as well as to fill the gap in the existing literature as most of the research has focused solely on

conventional warehouses. Thus we stress the differences between these types of facilities as well as the need to have tailormade tools for designing backrooms. Moreover, we aim to clarify the relationship between this promising research stream and the considerable body of research regarding the operations and design of conventional warehouses, as well as retail in-store operations.

- Secondly, we present a general framework for the design of backroom storage areas. The traditional design of the backroom areas is mainly established on the perception of the architect and on similar existing stores, when it should be carefully studied based on aspects, such as in-store logistics and operations, products flow and expected demand and inventory.
- Finally, we aim to develop a Decision Support System (DSS) to help designers to efficiently design backroom areas in a structured way which can be adapted to different types of stores (convenience stores, supermarkets and hypermarkets).

2 The Methodology

In order to tackle this problem a three-step approach has been followed, which is lined up with the three main objectives.

Firstly, key literature on backrooms, grocery retail, in-store operations, warehouse design and operations was reviewed. This allowed an understanding of the gap in the literature regarding the study of backrooms. In parallel with the literature review, we performed an exploratory work where retail stores of a Portuguese retail company were visited, which allowed to notice operational in-store problems and inefficiencies regarding backrooms. With this activity we were able to map the products' flow within the stores which will be the cornerstone for the layout definition and department organization within the backroom area.

Secondly, we have defined a conceptual model for designing the backroom areas that consists in seven sequential decisions and has the purpose to guide retailers in defining their backroom areas in a standardized and efficient manner. Succinctly, the first steps have the purpose of characterizing the new store regarding expected demand, products flow, number and type of departments, inventory in each department, necessary resources, among other requirements. These steps appear in the framework as follows: storage requirements, activity profiling, functional requirements and operational strategy. The following step uses the previous information to determine the storage space needed, resorting, for example, to a mathematical programming model. Once the space requirements are determined, the next step consists in determining the warehouse layout, allocating the departments in the warehouse, according to the products flow. The final step is the layout assessment regarding indicators previously defined with the design and operation teams. For that purpose a simulation model may be used.

This framework combines the frameworks found in the literature to design conventional warehouses and distribution centers into one single structured approach that is adapted to the reality of backrooms by handling the inefficiencies captured in the exploratory store visits.

Finally, we have been working closely together with the Portuguese leading food retail chain to tackle the backroom design problem and to develop a DSS to assist the designers in the store construction or remodeling processes. The DSS will be an instantiation of the concepts identified in the framework and can be adapted to other grocery retailers, with different requests deriving from different expected demands, products and departments organization as well as replenishment policies that have impact on the departments' size. The development of the DSS follows a sequence that may be characterized by four different phases:

1. Grouping stores into clusters which share similar space and sales patterns, using k-means and discriminant analysis;
2. Deciding which products need backroom storage, based on shelf space, products demand and replenishment policies;
3. Dimensioning each department resorting to a mathematical programming model with the objective of minimizing storage, construction, material handling and out-of-stock costs;

4. Defining the backroom layout, based on a mathematical programming model which considers the products flow and minimizes the distances between complementary departments and their sales area space.

3 The Value to Society

Apart from the scientific contribution in a topic that is rarely addressed in the literature, we also expect to achieve cost savings in the construction, storage and material handling of backrooms. Moreover we aim to minimize out-of-shelf situations that occur when products are not available in the shelves despite being stored in the warehouse. Other objective is to minimize the distances traveled by the employees between the sales area and the backroom, which could reduce work accidents and injuries. Overall, this project will improve backroom storage and increase client service level as well as store sales and productivity in retail food stores and, potentially, in other type of retailers with similar requirements.

Forecasting the medical workforce: a stochastic agent-based simulation approach

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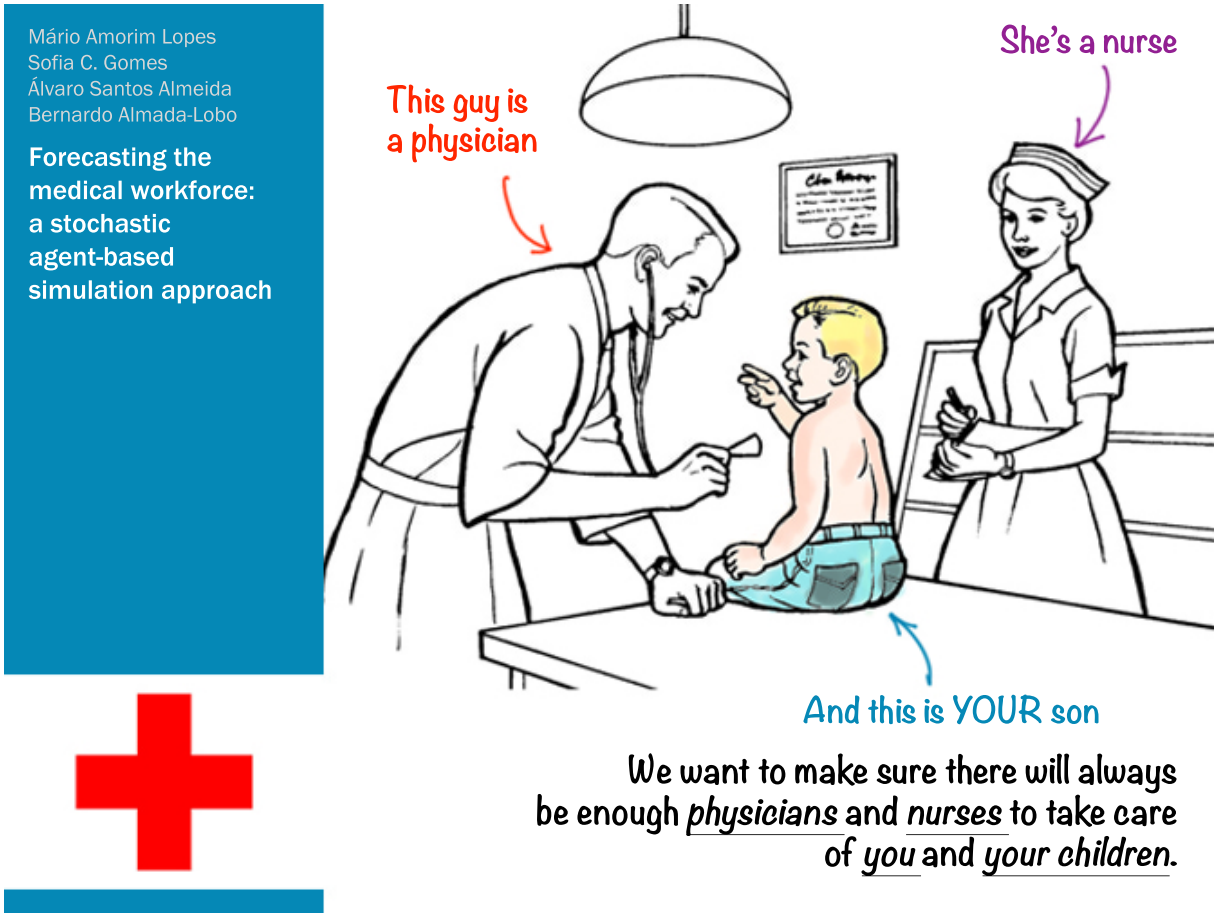


1 The Challenge

Health care delivery is a labor-intensive sector, composed of physicians, nurses, clinical assistants and other administrative staff. Imbalances in the supply of human resources for health (HHR) are known to cause severe economic and social harm, and may ultimately lead to patient deaths. Concern has been growing over a future lack of HHR, and the United Nations has included this pressing problem in their Millennium Development Goals. It is not an isolated problem, as a lack of medical staff in developed countries may divert scarce resources from developing countries.

As a result, several health authorities and academic institutions have been focusing on this problem. The work hereby presented is part of one such initiative, the EU Joint Action on Healthcare Workforce Planning and Forecasting. One of the main goals is to develop a robust model to forecast the evolution of

the medical workforce. After reviewing over 60 years of research in the field to understand how it evolved in terms of methodologies and its current state, we noted that no best or preferred solution exists, but there is a clear trend pointing to an integrated approach. Best practices suggest that such model should integrate both drivers of supply and demand for health care services, as well as epidemiological needs, productivity changes and skill mix. The latest papers published on the subject employ methods that target most if not all of these dimensions. Figure 1 exemplifies one such conceptual model.

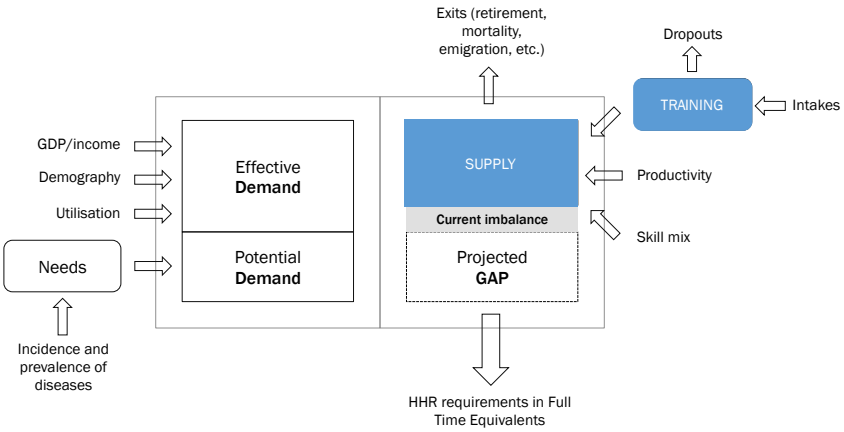


Figure 1: A functional description of a desirable model for healthcare workforce planning.

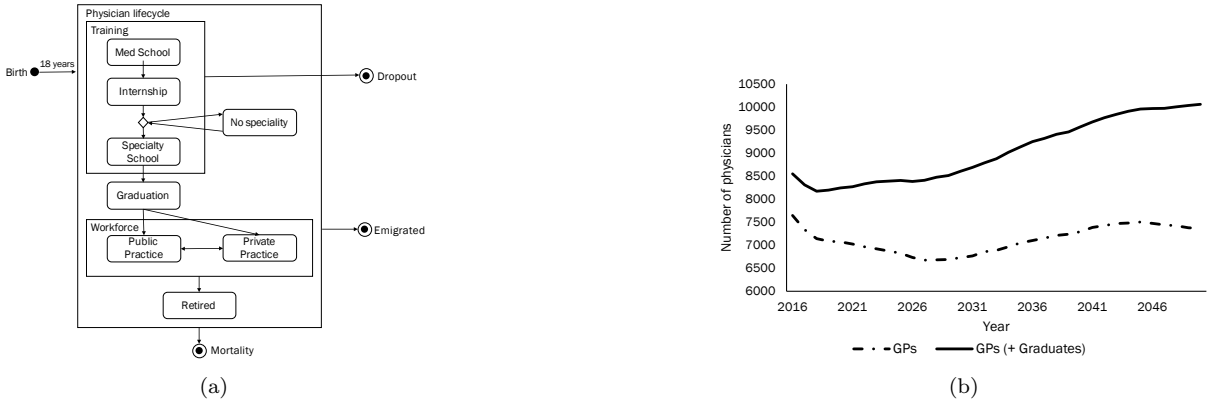
In this work we present a stochastic agent-based simulation model to address the supply side of the model depicted in Figure 1. As a case study, we have used it to forecast the supply of physicians (52 specialties) and nurses of the Portuguese health care workforce until 2050. To the best of our knowledge no such work exists, and the literature reviews consulted found no application of Agent-Based Modelling (ABM) to workforce planning, and very few exist to health care planning in general. The model is calibrated with real data reported by the Portuguese health authorities. The remaining componentes of the integrated model, in particular effective demand (i.e. demand for health care services effectively observed) and potential demand (i.e. unmet demand for health care services due to waiting lists, household budget constraints, etc.), as well as current imbalances will be addressed at a later stage.

2 The Methodology

To this purpose, and given the complexity of the system, simulation has been used extensively, in particular System Dynamics (SD). Several past works employ SD to generate forecasts of the health workforce. However, SD is facing challenges in modelling complex human behavior, including that of physicians and nurses. Its mechanical architecture of stocks and flows makes it difficult and unnatural to model complex human behavior that dictates, for instance, the decision to emigrate, whether a physician chooses public or private practice, or how they react to changes to wages. All of these cases are relevant to the matter at issue.

Notwithstanding the merits of such approach, we believe ABM is best suited to address this problem. ABM has been gaining importance in the field of health care, especially in the epidemiology literature, where it is used to model complex phenomena. It has several interesting benefits: i) it allows incorporating behavior rules and microeconomic foundations, such as an utility function and decision-making regarding migration, into the agents; ii) the agents' lifecycle can be modelled using state charts that are easy to visualize and understand, assisting in an external validation by experts in the field; iii) it makes it easy to define agent interactions, a feature particularly useful to study horizontal (between specialties) and vertical (between physicians, nurses, or any other agent) substitutability (skill-mix); iv) being a more intuitive process, policy-makers are more likely to understand results and policy implications. For instance, we can incorporate a labour market and foreign wage offers to study the impact on emigration. It is also possible to estimate the public sector wage bill as well as tuition costs, and use it to analyse trade-off scenarios where the Government accepts emigration and increases training places to offset the loss, or tries to retain physicians by increasing the wage bill, while seeing a reduction in tuition costs by

decreasing the training places.



(a) (b)

Figure 2: State chart for the Physician agent (left panel) and projections of the evolution of general practitioners (right panel).

We reproduced the expected lifecycle of physicians and nurses using state charts (Figure 2a), and implemented the set of rules that governs the health care sector in Portugal, in particular training places, contracts, specialty vacancies, etc. Every other parameter was calibrated according to real life data. The number of physicians (and nurses) is then aggregated in each state. As an example, Figure 2b provides the projections for the evolution of the general practitioners (GPs) in the medical workforce, including graduates. We also ran sensitivity and scenario analysis to assist with the validation of the model, since it is not possible to run backward projections due to lack of data.

3 The value to Society

Effective use and deployment of personnel is paramount to ensure an efficient service delivery in terms of cost, quality and quantity. Failure to do so may result in an oversupply or shortage of clinical staff. While the former may lead to economic inefficiencies and misallocated resources under the guise of unemployment or inflated costs through supplier-induced demand, the latter is linked to a more extensive list of negative effects, including but not limited to the following: lower quantity and quality of medical care as few resources exist to provide the necessary services and the visits are shorter; work overload of the available physicians and nurses, resulting in sleep-deprivation, ultimately compromising patient safety; and queues and waiting lists resulting from insufficient medical staff, causing avoidable patient deaths.

A mobility aware recommender system to foster the use of public transport

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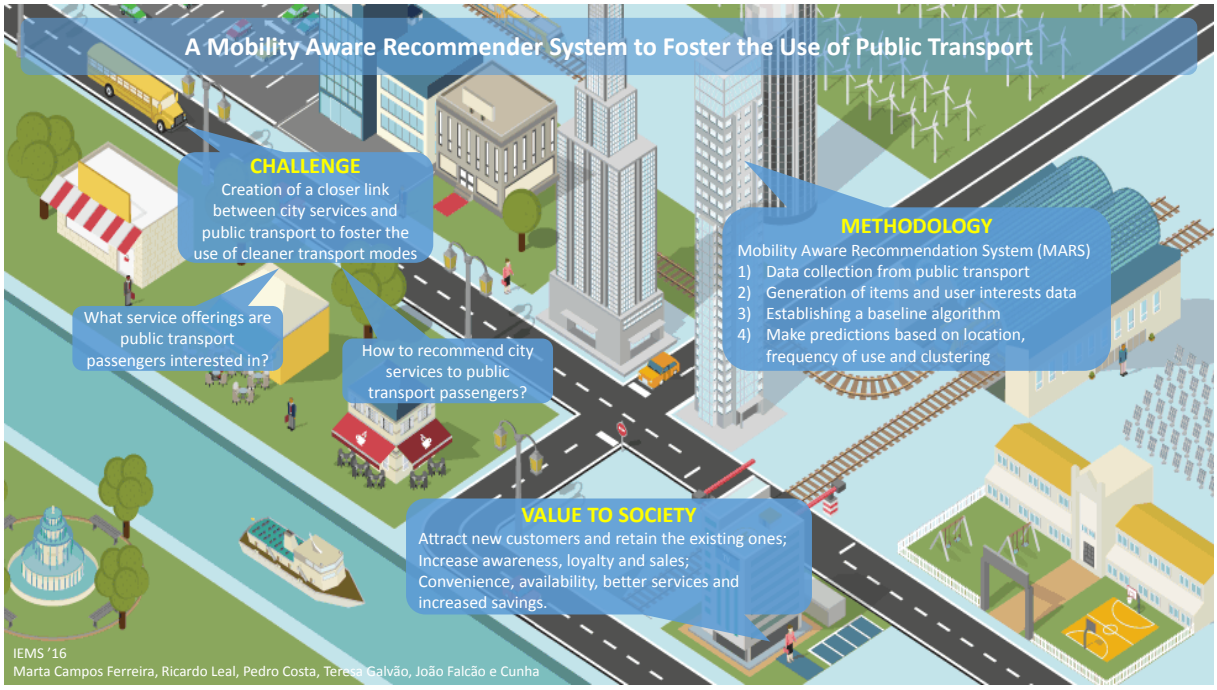

1 The Challenge

All over the world, cities are facing the same problems: congestion, road safety, security, pollution and climate change. These have negative economic, social and environmental impacts. Hence, it is crucial to promote the use of cleaner transport modes such as public transport. To achieve this goal, public transport must become more attractive by offering better service quality, accessibility and reliability.

New technologies are key to improve the public transport service, reduce the barriers of travelling with sustainable transport means and thus increase the use of public transport. Although there are several technological solutions that can be used to improve public transport service offerings, mobile solutions can support additional personalized functionalities, such as customized information and alerts.

Since every trip has a purpose (work, school, recreation, social), in order to foster the use of public transport, we advocate the creation of a closer link between city services and public transport. Nowadays, there are few initiatives that link public transport to other service providers; they work separately towards individual objectives. Moreover, if public transport operators want to partnership with other service providers it is difficult to direct marketing and communication efforts and is even more difficult to measure the impact of the initiative.

Hence, it is being developed a system based on mobile technologies that connects city services (e.g. restaurants, museums, groceries, cinemas) with public transport. The idea is to provide incentives to

public transport users such as offers from other service providers that may interest them. These offers may include vouchers, discounts, free trials or suggestions for certain events. The challenge here is how to direct these marketing and communication campaigns in order to make them effective, while limiting the effects of information overload.

2 The Methodology

One of the system components consists of a recommendation system. A recommendation systems is a software tool that provides suggestions to a user based on their explicit or implicit preferences, other users' preferences, user's characteristics or items' attributes. "Item" is the commonplace term used to denote what the system recommends to users. These systems can be divided in two main categories: content-based and collaborative filtering.

In this work, we analysed the integration of mobility in a recommender system with real data from a public transport network. Thus, the Mobility Aware Recommendation System (MARS) recommends items based on a combination of users' interests, mobility patterns on public transport and items' location and characteristics. The methodology applied to predict traveller interest in an item was divided in four main steps:

1) Data collection from smart cards from the public transport in Porto:

The transport provider manager, TIP, supplied the users' mobility data. A total of 136.32 million journeys were recorded in the year of 2013. From those, a subset was selected to test the algorithm. We further restricted the data geographically for an area of approximately 694 thousand square meters, from which a random set of 127 users was selected, resulting in 2463 passenger check-ins.

2) Generation of items and user interests data for testing:

Seven generic categories of interest were generated and the user interests were randomly generated for these categories. Each of these combinations was then paired with the mobility passenger data previously selected, resulting in a total of 127 user profiles with both mobility and interests.

3) Establishing a baseline algorithm:

The first step was to implement a simple algorithm without mobility data, to establish the baseline and investigate the results of the adaptation. Thus using both passenger and item profiles as vectors, the distance between them indicated the interest a passenger has in a certain item. To calculate the value we used the cosine similarity method due to its effectiveness and popularity, adapted to a binary based approach.

4) Adaptation of the baseline algorithm to make predictions based on location, frequency of use and clustering:

4.1) Location-based implementation: This approach calculates the location rating for the closest stop, allowing recommendations of items that are closer to stops used by a passenger.

4.2) Location- and frequency-based implementation: This algorithm introduces the frequency of use of a stop. The ideal stop (the one with the most check-ins) provide the basis for assessing frequency. Then, the most relevant stop (the one that is both close and frequently used) is calculated.

4.3) Clustering implementation: This implementation aims to achieve the clustering of all nearby stops and create the Super Stops. The Super Stops are stops with latitude and longitude calculated with the average of all stops in their respective clusters. The frequency is the sum of the frequencies of all the stops in the cluster.

The results obtained from the execution of the four proposed algorithms show successful recommendations of items adapted to users' mobility profile (see Fig. 1). Users had their recommendations lean towards the areas frequented. If users are interested in recommendations adapted to their mobility patterns, MARS has real value making recommendations for them. Future work include the introduction of the variable time in the algorithm and assessment of the real interests of the users either with social-networks or user

history in the system.

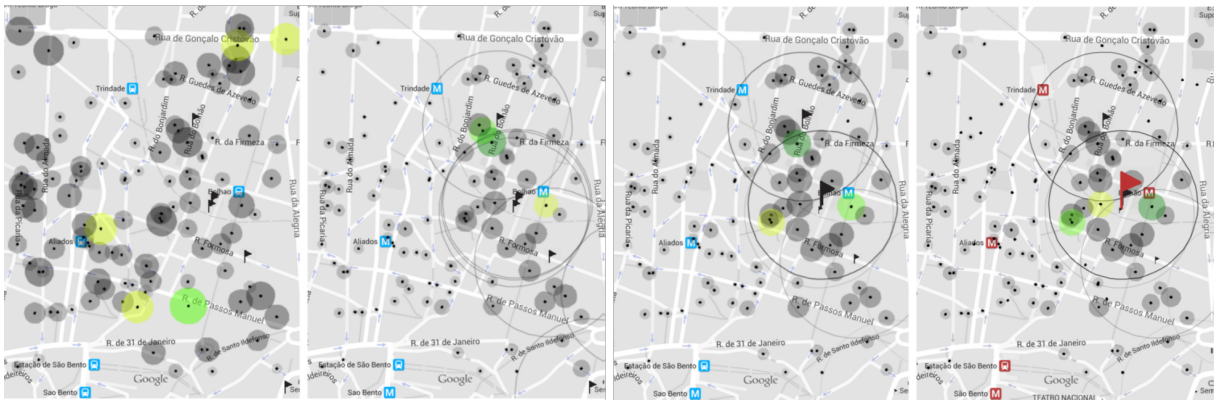

Figure 1: Recommendations for a single user using the four iterations of the MARS algorithm: baseline, location-based, location- and frequency-based and clustering (from left to the right). The flags represent stops, the circles items and the circumferences represent the stop radius. The top items are shown in a different colour, from green (highest) to yellow (lowest).

3 The value to Society

The proposed system allows an effective implementation of marketing and communication campaigns between city services and public transport. It contributes to modernize the image of public transport operators, improve quality of service, attract new customers and retain the existing ones, and increase the use of public transport services. Local businesses gain access to a vast client-base of public transport, and have the opportunity to increase awareness, loyalty and sales. Passengers benefit from convenience, availability, better services, and increased savings.

The impact of servitization on the performance of manufacturing firms over time: An empirical investigation in the elevator industry

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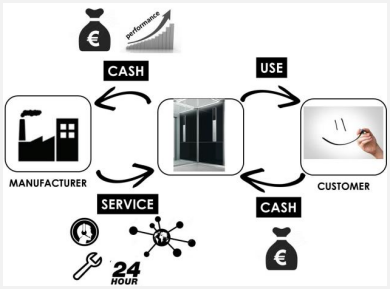
The impact of servitization on the performance of manufacturing firms over time: An empirical investigation in the elevator industry

Challenge

Although product-service combinations seem to provide higher revenues in comparison to offering the physical product alone, empirical evidence seems to suggest that servitized companies are delivering lower profits than pure manufacturing firms: the so called service paradox.



1. Only a limited number of empirical studies have considered the relationship between service provision and firm performance.
2. This relationship, as seen before, can be positive or negative.
3. It cannot yet be told reliably what kind of factors will lead to improved performance under which circumstances.
4. This suggests that there is still a limitation on the understanding of the performance impact of servitization in manufacturers.
5. Therefore, a more detailed understanding is needed on the impact of servitization on the performance of the manufacturing firm.
6. Moreover, the extant evidence suggests a complex relationship between service provision and firm performance.
7. Therefore, the simple advice to add services is not likely to always produce satisfactory performance outcomes.
8. There is also a strong need for more longitudinal studies, being in line with the argument that servitization is a long-term, often incremental process.

Value to society

1. Servitization, more than ever, may offer opportunities for manufacturing firms in developed countries to create value.
2. Technological advances, like new sensors and data capture systems, may open up new opportunities for service business model innovation in manufacturing firms around the world.
3. The consolidation and formalization of knowledge on servitization, so that the opportunities can be widely accessed by manufacturing companies and their customers.
4. This research will be helpful in guiding and providing manufacturing firms with a technical analysis so that they can properly decide if they will servitize (and with which intensity).

Methodology

RQ1: What are the relevant factors that affect the adoption of different servitization levels over time?
RQ2: What are the relevant factors that affect the performance of the servitized manufacturing firm over time?
RQ3: How do the relevant factors promote / hinder the different servitization levels over time?

1. A longitudinal quantitative data from the SABI database, which contains financial data from elevator companies in Portugal, Spain and worldwide (RQ1 and RQ2).
2. A content analysis of all internet sites of elevator companies in Portugal, only for the year 2015 (RQ1 and RQ2).
3. A content analysis of the financial annual reports of the main multinational companies that operate worldwide, over the last 10 years (RQ1 and RQ2).
4. A retrospective case study about a multinational manufacturing elevator company operating in Portugal will be performed, concerning a period of sixty years (RQ3).
5. To cover the perspective of the customer, a survey will be conducted to the customers of the elevator industry in Portugal (RQ1 and RQ2).

IEMS'16 7th Industrial Engineering and Management Symposium

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1 The Challenge

The boundaries between manufacturing companies and service firms are breaking down across the world. Today an increasing number of manufacturing companies is competing through a portfolio of integrated products and services. This is a services-led competitive strategy and the process through which it is achieved is commonly referred to as servitization. Therefore servitization can be seen as a transformation process that gives the manufacturing company the possibility to compete through product-service systems (PSS) rather than products alone. Simply put, servitization can be seen as a process of creating value for the company and for the customer by adding services to products.

Successful servitization demands that manufacturers adopt new and alternative practices and technologies

to those traditionally associated with production operations. A prevailing challenge is to understand these differences and their underpinning rationale. Although product-service combinations seem to provide higher revenues in comparison to offering the physical product alone, empirical evidence seems to suggest that servitized companies are delivering lower profits than pure manufacturing firms: the so called service paradox.

Much research has been dedicated to the design and benefits of integrated product service offerings. But only a limited number of empirical studies have considered the relationship between service provision and firm performance. This relationship, as seen before, can be positive or negative. It cannot yet be told reliably what kind of factors will lead to improved performance under which circumstances. This suggests that there is still a limitation on the understanding of the performance impact of servitization in manufacturers. Therefore, a more detailed understanding is needed on the impact of servitization on the performance of the manufacturing firm. Moreover, the extant evidence suggests a complex relationship between service provision and firm performance; therefore, the simple advice to add services is not likely to always produce satisfactory performance outcomes. There is also a strong need for more longitudinal studies, being in line with the argument that servitization is a long-term, often incremental process.

This research extends the literature by addressing the following three research questions:

RQ1: What are the relevant factors that affect the adoption of different servitization levels over time?

RQ2: What are the relevant factors that affect the performance of the servitized manufacturing firm over time?

RQ3: How do the relevant factors promote - hinder the different servitization levels over time?

2 The Methodology

This research project is based on the elevator industry. From a rigorous and in-depth analysis of this industry worldwide, and in Portugal and Spain in particular, we will try to measure the impact of servitization on the performance of elevators firms, based on longitudinal quantitative data from the SABI database, which contains financial data from elevator companies (over the last 13 years). This analysis will be complemented with a content analysis of all internet sites of elevator companies in Portugal (only for the year 2015) and another content analysis of the financial annual reports of the main multinational companies that operate worldwide (over the last 10 years). A retrospective case study about a multinational manufacturing elevator company operating in Portugal will be performed, concerning a period of sixty years. To cover the perspective of the customer, a survey will be conducted to the customers of the elevator industry in Portugal. The secondary quantitative data analysis, the content analysis and the customer survey will be used to address the research questions RQ1 and RQ2 and to test several research hypotheses. The case-based research will be adopted to answer research question RQ3.

Using a single industry, a more granular insight on the factors that impact on the performance of manufacturing firms can be obtained. These in depth insights are unobtainable from cross-industry accounting data, and will help shedding light on the factors that underpin the servitization paradox. A single industry analysis is used, because it may help to hold neutral the context variables that may influence the performance of all companies in that specific industry, in the same country.

By addressing an under-researched aspect of servitization, this study makes an important contribution in that it strengthens the theoretical foundation of the servitization literature.

3 The value to Society

Taking into account the changing structure of the global economy, servitization, more than ever, may offer opportunities for manufacturing firms in developed countries to create value.

Moreover, technological advances, like new sensors and data capture systems, may open up new oppor-

tunities for service business model innovation in manufacturing firms around the world.

Finally, and although servitization is not something new, the importance of researching this subject relies on the consolidation and formalization of knowledge on servitization, so that the opportunities can be widely accessed by manufacturing companies and their customers.

We expect that the outcome of this research will be helpful in guiding and providing manufacturing firms with a technical analysis so that they can properly decide if they will servitize (and with which intensity).

Towards an integrated approach to design for value co-creation

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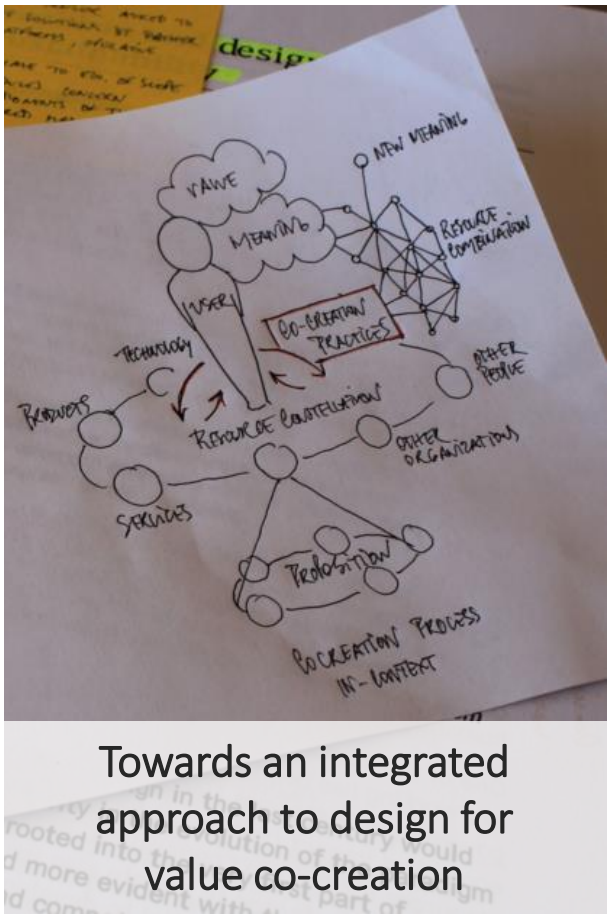

CHALLENGE

Supporting manufacturers that are interested in **infusing service** into their product offerings and **evolve towards servitization**

METHODOLOGY

Design and develop a new method that combines **contributions from service design and product-service-systems** field to **enable the co-creation of relevant and more integrated offerings**, while leveraging customer experience

VALUE TO SOCIETY

The new method will enable other industries to transit towards service; and **develop their global competitiveness** and provide **better service experiences**

MIT Portugal

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

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1 The Challenge

In the late 90's, both researchers and manufacturers acknowledged the importance and potential of services to increase competitiveness in saturated markets. As such, they started to develop strategies to transit from product-focused to product-service system (PSS) solutions providers. This transition process is currently known as servitization and involves a profound change of mind-set and long-term strategy in industries. Although coming from different research communities, PSS and servitization literature are closely linked and share common foundations. PSS solutions are characterized as a mix of products and services that deliver a required functionality to customers. Examples such as Xerox (from copier seller to document manager), Rolls-Royce (pay power-per-hour contract) or car-sharing management system PSS solutions are extensively mentioned in PSS and servitization literature. PSS focus on the use-asset, availability and performance of products. Also, PSS solutions are usually characterized by relieving customers from the ownership of the product (e.g. car leasing services, the customer pays for product availability and doesn't need to concern about maintenance of the car). PSS usually adopts a lean

approach to design efficient systems that balance business, environmental and social benefits. Although PSS methods have recently evolved to more network and systemic approaches, they still remain difficult to grasp for traditional manufacturers. Also, manufacturers acknowledge that further research is required to understand what "value" is, from customers' perspectives. Customer non-acceptance of PSS solutions is identified as one of the main barriers for PSS adoption. As such more human-centred design approaches should be integrated in current innovation approaches of industries. Accordingly, this work represents an effort to fill this gap by developing a new method that better leverage the customer experience within the PSS design process; and support manufacturers to evolve towards servitization.

2 The Methodology

The research method integrates the constructive perspective of Design Research (DR) with the rigour of Design Science Research (DRS) systematic method (conception, application and evaluation); and the hands-on approach of Service design-thinking. The work aims to create a new method that integrates contributions of Service design and PSS design fields through the lens of the foundational premises of the service logic. Service-logic is a perspective explored in the marketing literature. It posits that customers are always value co-creators; and that firms per se, cannot create value but rather co-create it with their customers. Although providing a new perspective regarding value co-creation, the service-logic requires to be operationalized. Recently, this perspective has been integrated with the service design discipline. Service Design is a creative, human-centred approach that takes customers' aspirations and competences as inspirations to envision and design new alternative service experiences. Stage 1. The conception and development stage of the DSR methodology focused on studying methods and tools from Service design and PSS design fields. Each tool was selected according to its relevance, purpose and adequacy to the design process; and an initial toolbox was created. Stage 2. The tools were applied in traditional laboratory manufacturing industry setting. Through a collaboration period of six-months, and by adopting a hands-on service-design thinking approach, the researcher conducted an intelligent laboratory embryonic service project, which aimed to design integrated product-service solutions; and further develop the new method. The project iterated between exploration, creation, reflection design stages. Through workshops, participatory design sessions, lectures and an iterative design process, new product-service solutions were created. The workshop and sessions involved customers, partners and collaborators of the company. Also, new tools that better leverage the physical evidences of the service (PSS constellation); and better connects value-in-use characteristics with value constellation networks (value constellation matrix), were developed. Stage 3. A final workshop was undertaken to discuss and evaluate the learning outcomes of the design team. Also, a questionnaire was distributed to collect feedback regarding the relevance of the new solutions developed, and importance of the new competences learned by the design team, marketers and manager of the company through the design process adopted.

3 The value to Society

The set of methods and tools previously selected were tested and refined to better support the company to design new propositions (or offerings) and co-create value with their customers and partners. In addition to the new offerings, the research case allowed to refine the integrated approach for designing new service concepts based on the customer's service system and value constellation. As mentioned above, the tools created (PSS constellation, PSS architecture) enabled the company to down-size and operationalize the conceptual ideas into integrated product service and system value propositions. Future work focuses on applying this new approach in new set of relevant contexts; integrate and infuse the PSS and Service design contributions such as the value co-creation concepts of the service-logic in the service design thinking process; and further refine the approach. This approach will support manufacturers to evolve their offerings and grow towards servitization. It also contributes for service infusion, which has been identified as a service research priority.

Balancing and lot-sizing mixed-model lines in the footwear industry

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1 The Challenge

In this project we aim at developing a system to solve balancing and lot-sizing problems in mixed-model lines in the footwear industry.

The Portuguese footwear industry is undergoing a period of great development and innovation. The numbers speak for themselves. In 2013, Portuguese footwear industry exported 95% of the production, valued in more than 1600M €, with the 2^{nd} highest price and for 150 world markets. It is a diverse sector, which covers different categories of women, men and children shoes, each of them with various models. New and technologically advanced mixed-model assembly lines are being projected and installed to replace traditional mass assembly lines. Obviously there is a need to manage them conveniently and to improve their operations. This work focuses on a problem in a real world environment.

Generally, the combination of models produces changes frequently. As a result, the work plan is constantly varying, and to cope with this situation the traditional flow lines are steadily being replaced by more

flexible and sophisticated systems. Therefore, shoe manufacturing is advancing technologically and must be very innovative.

Furthermore, it is important to have efficient and effective production lines, and that is why this research will be focusing on balancing and lot-sizing matters.

The work to be presented naturally faces various difficulties, some due to the need to simultaneously deal with different problems: balancing, scheduling and lot sizing. They may be considered as combinatorial optimization problems. The methods used to solve them are described briefly below.

Footwear manufacturing typically involves cutting, stitching and assembly processes, and prior to stitching and assembly there are other processes to prepare the workpieces to be sent to the following line. In the stitching line, the workpieces are put inside a box, which can move in any direction. Therefore, lot-sizing is a subject which will be addressed here.

One of the challenging matters is the management of a stitching line. Besides the need to balance the line, a lot-sizing problem, involving the size of the boxes moving in the line, must be tackled. The company associated with the project usually creates boxes around size 10 (components of pairs of shoes) but the "right" size is not really known. As mentioned, the study and test of different lot-sizes is an objective of this work (a small example is in figure 1).

Model	Order Quantity
A	18
B	30
C	23

Boxes	Sets		
	1	2	3
1	10	8	0
2	10	10	10
3	10	10	3

Figure 1: Production Order and Box Creation.

For that purpose it will be fundamental to develop and evaluate adequate effective solution methods. Different objectives may be considered, which are relevant for the companies, such as minimizing the number of workstations, and minimizing the makespan, while taking into account a lot of practical restrictions.

2 The Methodology

The main objective of this work is considering a new and advanced (stitching) line and devising balancing and lot-sizing solution methods to automatically find good results in a short time. That will be achieved by first creating an initial solution for line balancing using an adaptation of the Ranked Positional Weighted (RPW) method, then by scheduling the line using one of the dispatching rules which is Critical Path (CP), expecting to reduce the makespan and, finally, using one method based on the concepts of the metaheuristic Tabu Search (TS), is used fot the lot-sizing phase. The lot-sizing problem has, as objective, minimizing the makespan. The TS method will take into account different neighbourhoods. For this method to be effective, two neighbourhood spaces are considered.

In balancing phase a constructive heuristic is used to create an initial solution quickly and if possible, with a reasonable quality. A well-known heuristic, RPW is adapted to this case. The RPW takes into account two elements. First, the summation of task times that follow a selected task in the precedence

graph (this gives priority in selecting tasks by considering remaining task times) and second the position of the selected task in the precedence diagram (it is crucial for the precedence constraint). Then, the tasks are assigned to the workstations according to their RPW values.

Scheduling and lot-sizing problems are important optimization problems, due to their practical relevance and also for their complexity. The goal of a scheduling problem is to allocate sequences of tasks to give workstations while taking into account convenient objective(s). In this problem, the objective considered is the minimization of the completion time.

In what concerns lot-sizing, it was decided to use a method based on TS, which seemed quite appropriate for the concrete case. The TS algorithm keeps current optimal solution and the best solution while exploring a neighbourhood.

For this method to be effective, the various neighbourhoods have to be dissimilar enough to be able to escape from the local optimum of each other. Two neighbourhood spaces are used: one is based on changing the order of the sets (Figure 1) and the other by obtaining new after summing the quantities of existing sets. So, by exploring two types of neighbourhoods two versions of the TS method were explored: TS-One and TS-Two.

TS-One worked only with one neighbourhood space but TS-Two used both spaces at the same time. TS-Two used more time but it was more effective. In addition various tests were performed to analyze the impact of changing the size of the lots while creating the boxes moving in the line.

3 The value to Society

This country is one of the major players in the footwear industry, ranking 6^{th} worldwide and 3^{rd} in Europe. The work concerns stitching lines in the footwear industry. A particular new stitching line was studied and some solution methods were devised, programmed and tested. At the same time, the possibility of extension and adaptation of the results to similar situations in other companies was taken into account.

A new mixed-model assembly line is studied. The problem is considered first balancing and then lot-sizing. The goal is to minimize an entire production cycle. In addition, in order to know the behaviour of the algorithm under different conditions, it was tested on different real instances of the company and the results are validated. Besides, the algorithm is quick and according to the changes it is easy for the company to run in different times in a day and it could be used for real world cases.

Finally, this work may also provide insights for balancing, scheduling and lot-sizing problems in other similar process industries.

Ship design as a Complex Engineering System Design

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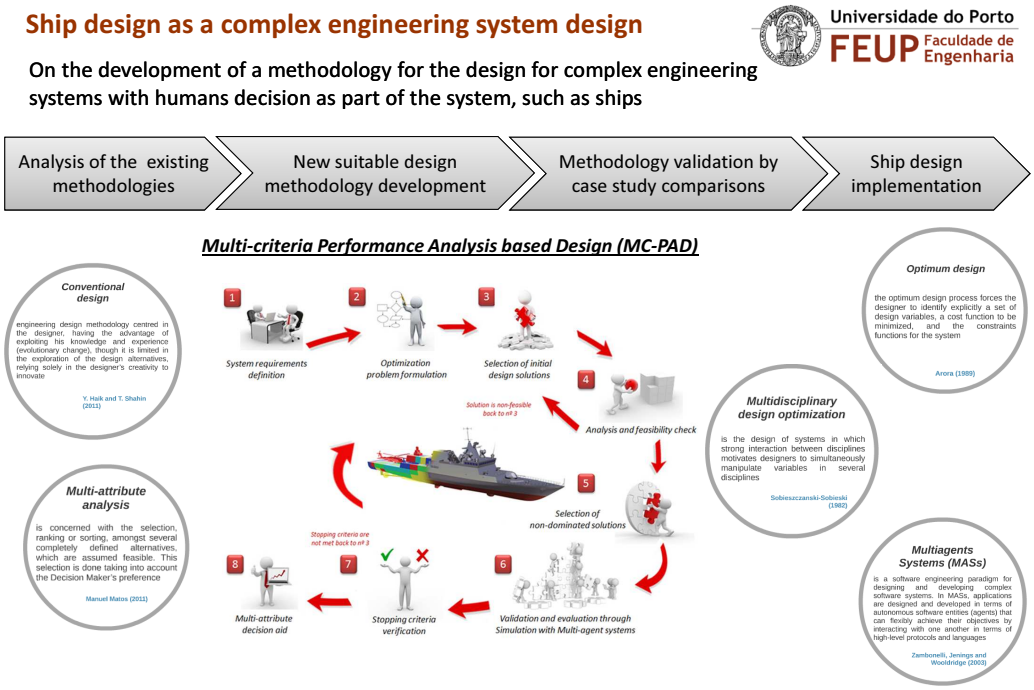

1 The Challenge

Engineering complex systems are man-made systems that aggregate at least some technological artefacts (hard or soft), and other elements or sub-systems of different natures. Due to their complexity either in variables quantity and interrelation between elements, their overall performance is not possible to be deduced from the individual analysis of each one of the smaller sub-systems and elements that compose them. Some of the elements and sub-systems that may be found in these systems are products (hardware, software, and firmware), processes, people, information, techniques, facilities, services, and other support elements.

Ships are an example of such systems. When designing a new ship concept, its hull geometry, structure, propulsion plant and other sub-systems must be brought together in a single final product, bearing in mind that when maximizing one's performance, the performance of others may be affected due to their interdependency. Further, ships' performance is not only dependent on its physical design characteristics, but also it is strongly influenced by human intervention. In other words, ships are complex engineering

hard systems made of several sub-systems (including the crew elements interaction), whose interdependency doesn't allow deducing their performance from individual analysis of the smaller sub-systems.

Therefore, the challenge is to specify the process, the related activities, tasks and/or techniques that must be manipulated to solve the ship design problem, and reach an acceptable solution, amongst several candidates. In other words, to develop an engineering design methodology appropriate to develop complex engineering systems with humans in the loop.

2 The Methodology

First into developing a different approach to engineering complex system's design is to make a conceptual comparison between different design methodologies taking into account several comparison points, such as: i) the capability to explore over the search space of all possible design alternatives; ii) the capability to find several non-dominated design alternatives with a set of multiple and conflicting design requirements (multi-objective); iii) the capability to incorporate human decision as part of the engineering system; iv) the capability to select a single preferred solution between several non-dominated solutions taking into account the preferences of the design sponsor that works as a decision maker (DM). Once the pros and cons of each one of the existing design methodologies have been analysed, a new methodology can be developed making use of deductive reasoning. Afterwards, in order to validate it, the new design methodology must be compared against others making use of a simple study case for that purpose, where its advantages can be brought to light. Finally, the main problem of engineering complex system's design can be addressed, making use of the new methodology to design complex engineering systems such as ships.

Following the described research procedure, soon enough it was found that a complex engineering design methodology must incorporate elements of different existing methodologies and techniques such as: i) multi-disciplinary design optimization (MDO); ii) robust design; iii) multi-attribute decision analysis; iv) simulation using multi-agent systems (MAS). This analysis, lead to the deductive development of the Multi-Criteria Performance Analysis based Design (MC-PAD) represented in the figure. Within this process step number two is of extreme importance since it consists upon the mathematical formulation of the design problem as a multi-criteria problem and its decomposition while maintaining design variables coupling. In other words, primarily, design requirements, assumptions and success criteria, are translated into objective functions, constraints, design variables, DM preferences and performance measures; secondly, interrelation between variables is analysed in order to define how to decompose the problem without losing information and maintaining interdependency between sub-systems that characterise the complex system. Next, the developed methodology had to be tested against other existing design methodologies by comparing the design solutions found for a small complex system that incorporates human decision process. Lastly, the developed methodology has been applied to designing a medium size ship for operations of public interest, including sea rescue, disaster relief and fishing inspection.

3 The value to Society

With this work we expect to contribute in developing an integrated approach to design engineering complex systems that rely on human decision for their operation, and that may take into account very different requirements.

In the particular case of ship design, in today's society they are essential to world-wide economy, without which intercontinental trade, the transport of raw materials and the import/ export of goods would not be possible at affordable prices. Only in the case of Leixões, in 2014 the annual traffic of cargo reached 18.000.000 t.

Nonetheless, ships are not only used for maritime transport, and there are ships specially designed to conduct other services, such as cruise ships, offshore support, fishing ships and maritime rescue. The value of the two first examples is unquestionable, and as far as the fishing industry is concern, official statistical data shows that only in Portugal in 2012 about 200.000 t of fish were sold in the fishing markets at a mean cost of 1,8 Euro/ kg (equivalent to 360 million Euro).

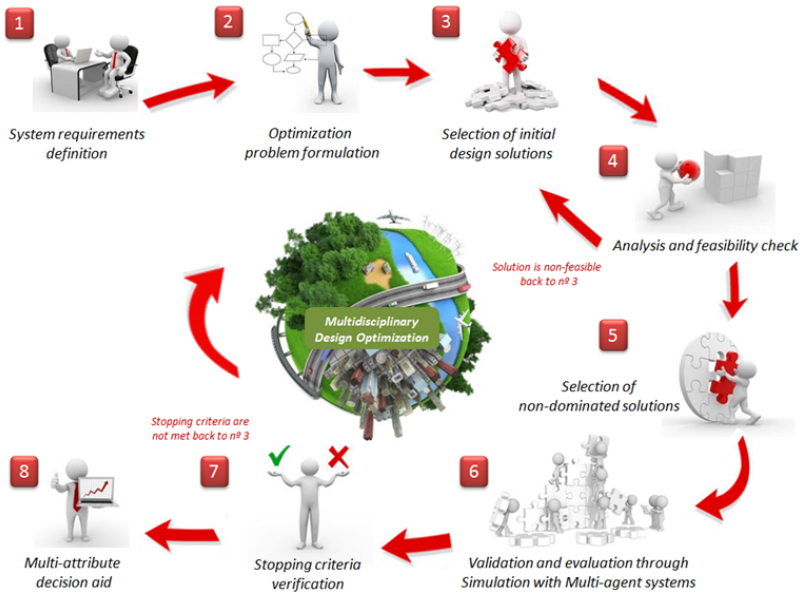

Figure 1: Multi-Criteria Performance Analysis based Design (MC-PAD) Methodology.

All in all, the foundation of this study is that not only ship design as an engineering complex system is important and necessary, but also that the developed methodology may be used in the design of several different complex systems in the future.

The assessment of eco-efficiency of multinational mining companies

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1 The Challenge

Minerals and metals are fundamental raw materials for contemporary society, as they are core supplies for supporting human life in the planet. These materials are essential for several sectors, ranging from basic industries to the entertainment industry. The high global demand for mineral commodities has led to the development of one of the most environmentally impactful economic activities on the planet: mining. Therefore, assessing the eco-efficiency of large mining companies is crucial to ensure the creation of wealth without compromising the needs of future generations. This work aims to expand the traditional concept of eco-efficiency, through incorporating new criteria into an enhanced assessment framework based on a directional distance function (DDF). These new criteria are denominated environmental benefits (e.g., the use of renewable resources and conservation efforts), that complement the traditional dimensions of eco-efficiency, representing economic benefits (e.g., production of value-added) and environmental burdens (e.g., air emissions and spills).

2 The Methodology

Our real world application explored a sample of 25 multinational mining companies that published their environmental and ecological outcomes in sustainability reports. The companies studied are affiliated to the Global Reporting Initiative (GRI) and 20 of them are members of the ICMM (e.g., Vale and Rio Tinto). The data sources for this article are the sustainability reports of mining companies and their financial statements. This information is in the public domain, and is voluntarily published by companies on an annual basis. The reference year of assessment is 2011, which is the year with the smallest number of missing values in the dataset.

In this paper we extended the concept of eco-efficiency from the World Business Council for Sustainable Development (WBCSD), which consists of keeping the business competitive while reducing material and energy requirements, minimizing the dispersion of toxic wastes and maximizing the sustainable use of renewable resources. The selection of the dimensions to incorporate in the assessment of mining companies took into account the criteria identified in some of the major international guidelines for environmental management (e.g., the ISO 14000 family of International Standards, GRI and ICMM guidelines). After identifying the main dimensions to be taken into account in the efficiency assessment, a literature review was conducted to ensure the alignment of the dimensions selected with previous eco-efficiency studies, in the mining industry as well as other sectors (e.g., agriculture, manufacturing and electricity sector). Finally, the set of indicators presented in Table 1 was selected in order to operationalize the dimensions taking into account the data available in the GRI reports.

In this expanded framework, the firms' economic value-added (Y_1) expresses the organizational capability of generating wealth for stakeholders. The environmental dimension is organized under the structure of an accounting balance sheet.

Table 1: Enhanced eco-efficiency framework.

ECONOMIC DIMENSION	
Value-Added (Y_1)	
ENVIRONMENTAL DIMENSION	
BENEFITS	**BURDENS**
Use of renewable resources (R)	**Use of non-renewable resources (N)**
Renewable energy consumption (R_1)	Non-renewable energy consumption (N_1)
Recycled water consumption (R_2)	Withdraw water consumption (N_2)
Conservation (C)	**Dispersions (D)**
Environmental investments (C_1)	Wastes (D_1)
Protected areas supported (C_2)	Air emissions (D_2)
	Spills (D_3)
	Environmental fines (D_4)

The quantification of the extended eco-efficiency measure, exhibited in model (1) was accomplished using a DDF model involving an equal treatment of all indicators representing burdens to be minimized, irrespectively of their intrinsic nature being an input or an undesirable output. The assessment we propose involves an optimization with two stages. The first stage seeks for performance improvements through the minimization of the total resources consumed ($R+N$) and Dispersions (D) and maximization of two other categories of indicators (i.e., conservation (C) wealth generated (Y)). The second stage explores improvement opportunities in the composition of the resources consumed, in order to become greener by replacing non-renewable resources with more sustainable alternatives. This second stage optimization is another innovative feature of our eco-efficiency model. Another contribution of our research is the ability to explore different scenarios regarding managerial priorities for adjustments to firms' economic and environmental indicators. This is achieved by changing the directional vector $g = (g_{Y_r}, g_{C_q}, -g_{D_l}, -g_{T_i})$ specified in the DDF model. This paper presents four potential scenarios, corresponding to the use of different directional vectors reflecting the priorities for adjustments to firms' benefits and burdens.

$$\max \beta_k + \sum_{i=1}^{I} S_i \tag{1}$$

$$\begin{aligned}
\sum_j \lambda_j Y_{rj} &\geq Y_{rk} + \beta_k \; g_{Yr} \quad r = 1, ..., R \\
\sum_j \lambda_j C_{qj} &\geq C_{qk} + \beta_k \; g_{Cq} \quad q = 1, ..., Q \\
\sum_j \lambda_j D_{lj} &\geq D_{lk} - \beta_k \; g_{Dl} \quad l = 1, ..., L \\
\sum_j \lambda_j T_{ij} &\geq T_{ik} - \beta_k \; g_{Ti} \quad i = 1, ..., I \\
\sum_j \lambda_j \rho_{ij} &= \rho_{ik} + S_i \quad j = 1, ..., J \\
S_i, \beta_k, \lambda_j &\geq 0
\end{aligned}$$

Concerning the results of the assessment, 17 firms were categorized as efficient whilst eight firms were classified as inefficient. The classification of DMUs is independent of the choice of the directional vector used for the assessment, but the magnitude of the eco-efficiency score is affected by the preferences specified in the directional vector (varying from 0.521 to 6.734 on average). The greatest opportunities for adjustments were identified for the scenario focusing exclusively on improvements to conservation practices. Regarding the proportion of renewable resources used by the mining firms, the percentage of renewable energy and recycled water can be improved, on average, 8% (from 9% to 17% in the case of energy and from 12% to 20% for water).

3 The value to Society

This study proposed two theoretical enhances to eco-efficiency assessments with value to society. The first consists of advances in the traditional measure of eco-efficiency to include environmental benefits associated with firms activities. Incorporating these new features in the eco-efficiency analysis can help the design of corporate policies to improve economic performance alongside the reduction of impacts on local ecosystems or the depletion of natural resources. The second enhancement lies on the development of an enhanced directional distance function model that also optimizes the proportion of renewable resources used by firms. Future research intends to focus on the the assessment of efficiency change over time, so that the evolution of economic, environmental and social practices can be tracked systematically.

Acknowledgements

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Planning Product-Delivery Modes For Grocery Retailers Stores

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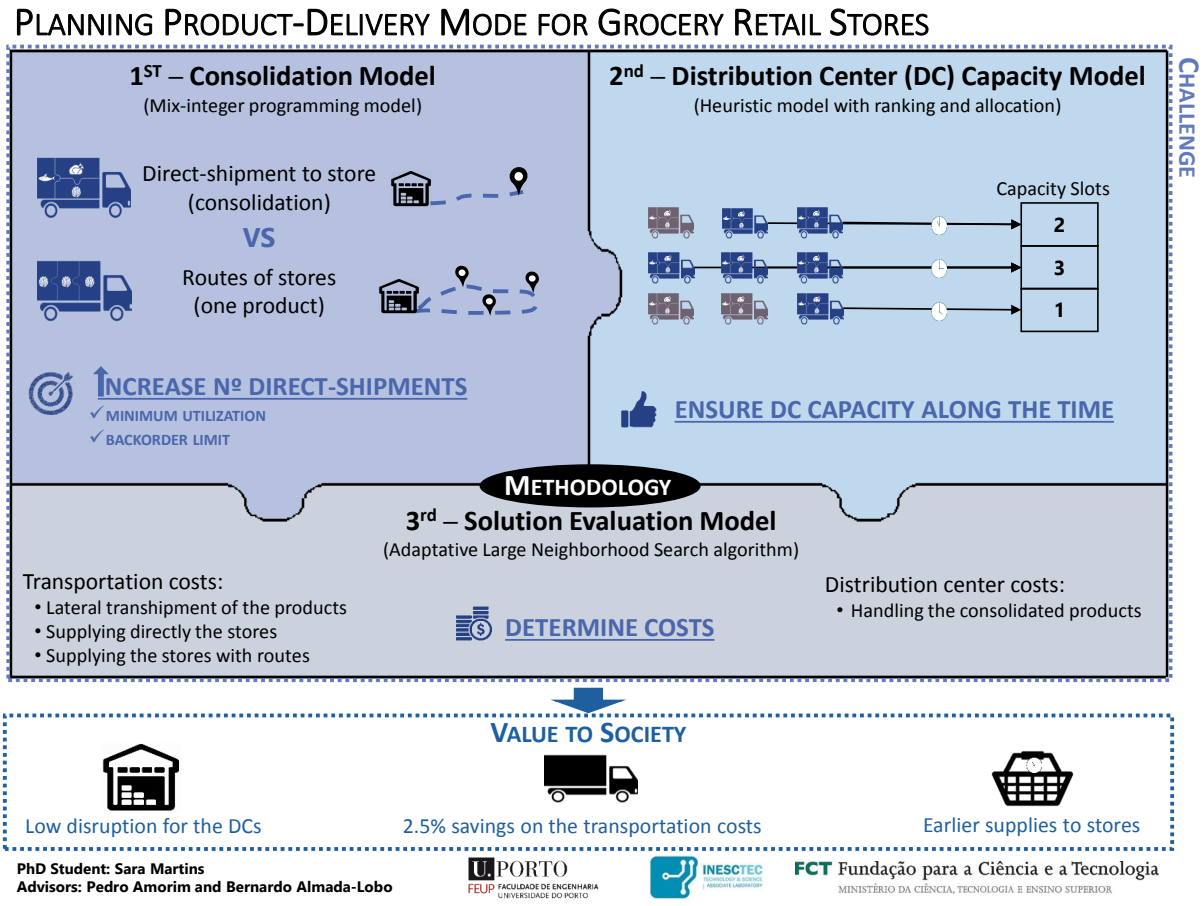

1 The Challenge

Retailers play an important role in supply chain management as they are often the closest link to the final customer. Their internal supply chains incorporate typically the processes of procurement, warehousing, distribution and sales. Formerly, retailers operated only their stores, but nowadays the ones with a larger network also manage their own distribution centers (DCs). By using DCs new operational opportunities can be achieved, such as shorter lead times in the stores replenishment and consolidation of products from different suppliers.

In the food retail sector, maintaining the food quality across the supply chain is of vital importance. The quality of the products depends on its storage and transportation conditions. This peculiarity increases the supply chain complexity relatively to other types of retailers, leading to three types of food supply chains: frozen, chilled and ambient. Moreover, food retailers run different stores formats, with different

sizes, assortments and sales volume. To be closer to their customers and promote a convenience shopping experience, retailers are opening new stores every year in new locations.

Although products with different temperature requirements need to be stored separately, in the same DC or not, they can be transported together (consolidation) as long as the required transportation conditions are ensured. In this context, as there are different possibilities to distribute the products through the stores, retailers are posed the following question:

How should each store be supplied for different products in a cost-effective way?

This is a combinatorial problem as each store can be supplied separately for each category of products (temperature) or combinations. However, these combinations have to take in consideration several business restrictions:

- Stores have time-windows pre-defined for the products according to their replenishment policies that need to be secured;
- The preparation times in the different storage temperatures might be distinct and some consolidation combinations might not be possible;
- DCs have finite capacities which may constrain the consolidation of products as it increases the flow of material that passes through the DC.

Besides the business restrictions, which can be seen as hard constraints of the combinatorial problem, there are other conditions related to different alternatives for supplying a store. A store can be supplied directly by the DC, with freight of different temperatures consolidated or not, or in a route of stores, where multiples stores are loaded into a vehicle that perform multi-drops.

To understand the balance between the distinct ways of supplying a store different characteristics have to be taken in consideration as well as their interdependencies:

- When a full-truckload (FTL) is secured for one store the direct-shipment is obviously the choice, because there is no space left for additional freight to make a route. However, when the utilization of the vehicle is below 100% but still high it is not clear what the best solution is.
- The utilization of a vehicle to make direct-shipments to a store depends on the consolidation decision made for it;
- It might happen that for a given day a store demand can reach an FTL, but leaving behind some freight, which can be considered as a backorder. Depending on the service level that the retailer wants to ensure for their stores the possible consolidations might be constrained by the number of backorder occurrences allowed for each store;
- In terms of operationalizing a given supply decision to a store, for both the DC and the transports, it is different to perform the same type of consolidation in all periods or with flexibility to be changed periodically.

2 The Methodology

To identify the more cost-effective way to supply the stores a three step approach is used:

1. **Consolidation Model**

   Because there are different combinations for consolidating distinct categories of products and because the related decision impacts the utilization of the vehicles and backorders level a mixed-integer programming model is formulated to identify the best type of consolidation for each store. The

goal is to maximize the number of direct shipments to each store taking into consideration the operational characteristics defined, such as the minimum utilization of the vehicles and the flexibility to change the consolidation along the time.

2. **Distribution Centers Capacity Model**

   The DC, where the consolidations are performed, might not have enough capacity to consolidate all the stores provided by the optimization model (step 1). Therefore, the stores with potential to be supplied directly with products consolidated are ranked to define the priority of allocation to the DC.

   The stores are then allocated to the DC slots of time according to their time of preparation, which is dependent of the time-window pre-defined, time of travel and time of loading the freight. The store is allocated to the DC in case the capacity of the latter holds. The non-allocated stores are not eligible to consolidate and therefore should be supplied with routes.

3. **Solution Evaluation Model**

   This step considers three components of cost, namely the transportation cost of supplying directly the stores that consolidate, the transportation and warehouse cost of moving the products to the consolidation DC and the transportation cost of the remaining stores being supplied with routes. For quantifying this last term, the Adaptative Large Neighborhood Search algorithm is used to construct and evaluate the routes for the different categories of products.

3 The value to Society

This methodology was used in a case study of a Portuguese Food Retailer. The objective of the company was to identify the best way to supply their stores in order to reduce their global costs, with smaller impact on the current service provided to the stores. Transportation costs of supplying the stores and performing consolidations on the DC were considered, as well as the operational complexity of the procedures selected. The final results demonstrated annual savings between 2.5% and 4% depending on the flexibility to adjust the DC operation times. Guidelines on how each store should be supplied were provided to the company and will be used in the next year.

In this case-study the perspective of all the stakeholders was taken into consideration when evaluating the solution. It was chosen a solution where the type of consolidation is maintained along the time, which is easier to operationalize for the DC. The stores for which the type of supply was changed receive now more products together and at an earlier hour, which allow the shelfs to be replenished sooner. Finally, the transports see their annual costs reduced by at least 2.5% with little adjustments in their current processes.

Although this work focuses on the case of food retailers supply chain, due to the complexity of supplying products with different temperatures, this approach can be adopted by other retailers that have products allocated to different DCs. One example of other application is the case of retailers that have a centralized DC for slow movers and need to decide whether they should be consolidated with the other products. Moreover, this work will be extended to include other distribution decisions that impact the distribution planning and that could change the customers' service level.

Acknowledgments

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An Ontology-based Approach to Visualizing Urban Mobility Data

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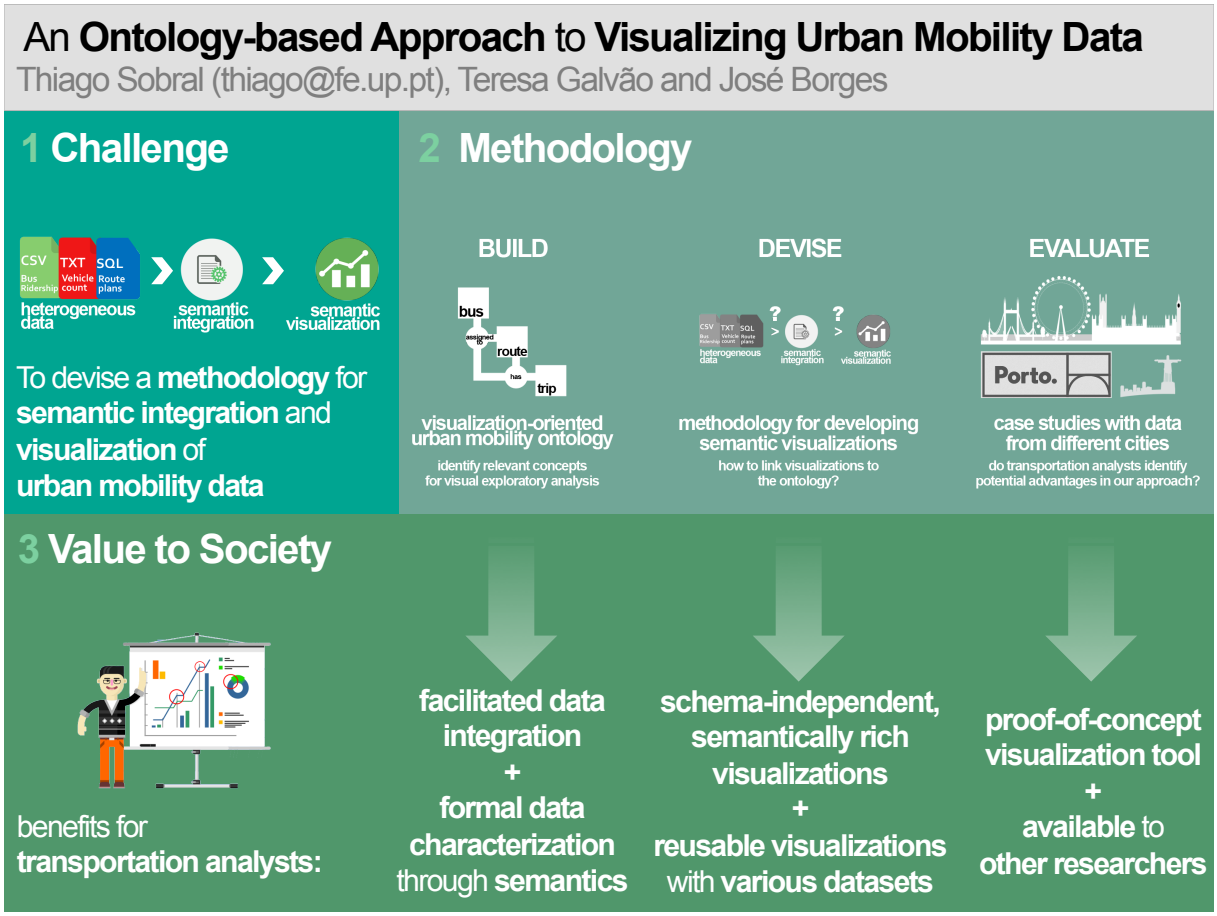

1 The Challenge of Visualizing Urban Mobility Data

Intelligent Transportation Systems (ITS) are one way of tackling the ever-increasing urban mobility challenges. ITS combine Information and Communication Technologies (ICT) and physical infrastructure. ITS generate a substantial volume of data related to citizens' travel habits, transportation ticketing and the like. Outputs from ITS are powerful for better understanding and devising actions towards improving mobility in urban centers. Nonetheless, data is not always explored in depth, thus suggesting a dichotomy between information abundance and knowledge starvation.

Our challenge consists of devising a methodology capable of fostering the use of Information Visualization in the domain of urban mobility. Concretely, our methodology would allow the semantic integration of urban mobility data, for visualization purposes. We present the issues that motivate and confirm the relevance of this challenge:

- Issue 1 (Availability): Transportation analysts still do not take proper advantage of visualizations, due to the scarcity of dedicated means for visualizing data. Urban mobility data cannot be fully explored with traditional visualization solutions such as *Tableau* or *Microsoft Excel*, given the intrinsic complex data characteristics and the spatiotemporal nature of data.

- Issue 2 (Data Heterogeneity and Complexity of Visualization Tools): Urban mobility data is heterogeneous, in two ways: it can be represented in distinct formats such as plain-text files or database dumps. Also, each dataset has a schema according to the specifications of each ITS manufacturer. Integrating that data for a joint analysis is often a time-consuming task, and not all analysts are prepared or willing to do so. Although there is a myriad of frameworks for developing visualizations, they require specialized programming knowledge, remaining as an additional obstacle for those analysts. In brief, there is enough technical advance available for specialized users, although the practical outcomes still do not reach or benefit analysts properly.

- Issue 3 (Schema-dependency and Reproducibility): Related literature presents visualization techniques for urban mobility analysis. Those techniques are generally restricted to a dataset with a particular schema. Moreover, it is often unclear how one can reproduce them. Those issues may limit their scalability in similar contexts by others. This issue highlights a gap between theory and practice.

2 The Ontology-based Approach

The approach we envisaged for addressing this problem comprises the use of Semantic Web Technologies (SWT), mainly ontology modeling. An ontology is a formal specification of concepts of a certain domain, along with their properties and interrelationships (see Figure 1). By formal we mean that all elements of an ontology are specified through statements that follow the rules of Description Logic. In the domain of urban mobility, studies that used SWT were centered on the development of solutions that could be used by passengers within a transportation network, notably in route planning tasks and touristic information retrieval. To the best of our knowledge, no studies used those technologies for the purposes of visualizing data. Our research consists of the following steps:

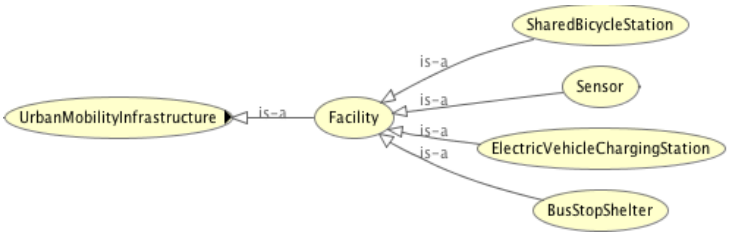

Figure 1: A small excerpt of an ontology of urban mobility concepts.

1) Developing a visualization-oriented urban mobility ontology: The ontology should include concepts that are relevant for visualizations of urban mobility data. Those concepts are identified by studying a diversity of datasets from complex transportation systems of cities like Porto, London and Rio de Janeiro. Our ontology is being developed in Web Ontology Language (OWL[1]), since it is acknowledged as the current standard for building ontologies. After the ontology is built, it will be possible to map data onto it, providing semantics to data and establishing integration for the further steps.

2) Building a methodology for developing visualizations of semantic urban mobility data: We should build a pipeline that may allow visualizations to directly communicate with the ontology. By taking advantage of a logical rule language like Semantic Web Rule Language (SWRL), it will be possible to express complex logic rules that can define specific properties of each visualization technique, such as the type of data they support (according to our ontology), which can automate and facilitate the process of selecting an adequate visualization.

3) Developing a proof-of-concept prototype: In order to exemplify and assess the relevance of our approach, a visualization tool prototype will be developed and evaluated with transportation analysts.

[1]The creators of the Web Ontology Language coined the acronym OWL as they found it easier to pronounce than WOL.

The prototype will be coupled with real urban mobility data, thus counting as case studies.

We acknowledge that a user-centric approach is needed. Analysts, as end-users, can provide vital information about what characteristics in urban mobility data are of interest for the purposes of visualization. Therefore, analysts will be involved periodically in order to evaluate our outcomes. Figure 2 illustrates an overview of our approach.

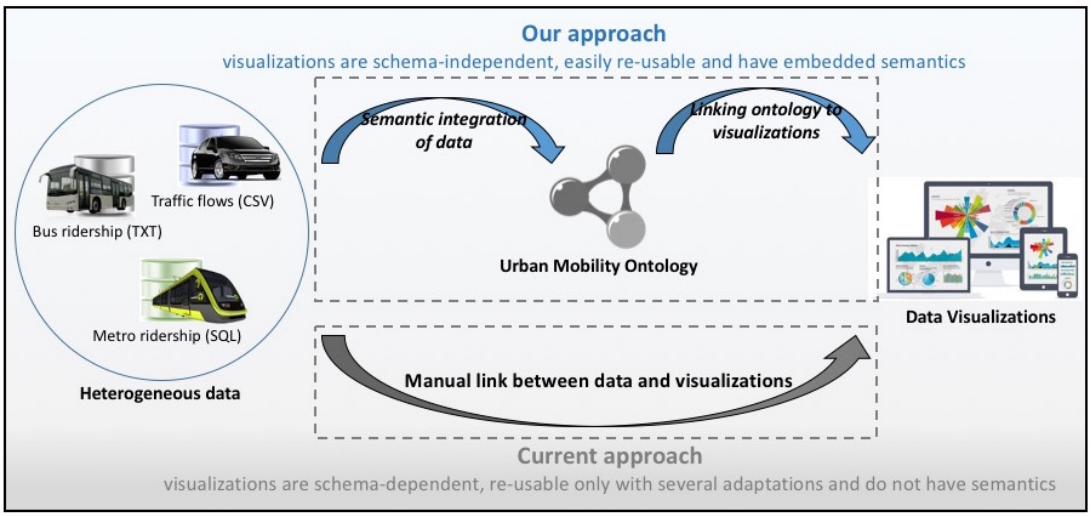

Figure 2: A comparative illustration between the existing approach and our proposal.

3 The value to Society

We expect that our work may help shifting the researchers' focus, towards developing visualizations that can effectively reach transportation analysts. The development of an urban mobility ontology aims to simplify the task of data integration, thus solving the issue of heterogeneity. The ontology can also be used and extended by others in order to meet the uniqueness of many urban mobility contexts. Visualizations developed according to our methodology are expected to eliminate the problem of schema-dependency, as they would communicate directly with data linked to our ontology. Eliminating this problem would also improve reproducibility, given that visualizations could be easily adapted to other datasets.

End to End Abstracts

Leveraging the printing plant production scheduling

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The printing plant is one of the most challenging environments for production scheduling activities. The main reason comes from the fact that the number of operations required to complete a job is not pre-defined, since it will depend on the machines selected to perform the job. This highly flexible setting explodes the number of possible production schedules. Furthermore, the problem cannot be easily decomposed due to the strong interdependencies among all decisions. Colep faces this challenging problem when scheduling the printing and varnishing stages of its metal packaging production. To support this challenging planning task a decision support system (DSS) was developed. The DSS is allowing the company to standardize the underlying scheduling processes and save significant time to the planners. Moreover, it improves the quality of solutions with state-of-the-art models and innovative solution methods. Increased visibility of the schedules is also guaranteed, which is of upmost importance due to the need to accommodate rush orders and to deal with shifting bottlenecks between the production resources. The DSS is fully configurable (all parameters can be adjusted, including production setups, machine compatibilities, planning slacks and optimization routines) and interactive (the user can fix complete schedules or parts of it, impose stoppages, etc.). The DSS is also seen as a tool to test alternative production strategies and perform what-if analysis.

Improving the distribution master plan of a food retailer through supply chain analytics

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Large food retailers have to deal with a complex distribution network with multiple distribution centers, different temperature requirements, and a vast range of store formats. The distribution master plan of retailers incorporates different decisions that impact the processes along the supply chain, such as product delivery modes planning (direct shipping and/or hub-and-spoke) and product-warehouse-outlet assignment (assignment of stores and products to distribution centers). To be closer to their customers and promote a shopping experience with more proximity, Sonae MC is opening new stores every year in new locations. While in the past most of the stores that the company supplied were of large size (supermarkets and hypermarkets), nowadays, the smaller stores impose new challenges to the distribution process, since the demand is more fragmented. Moreover, the freight to distribute is now more heterogeneous than previously. Using a simulation-optimization approach we were able to rethink the distribution master plan of Sonae MC by identifying the distribution rules that best fit the new market dynamics. The new distribution master plan allowed to reduce the distribution costs significantly and improve the stores' service level by making earlier supplies with consolidated freight. Finally, the proposed methodology allowed to verify the impact on the different processes of the supply chain and ensured the feasibility of the solution to be implemented.

Shortcut - Combining Simulation and Optimization to Improve Picking Performance on Specialized Retailer Warehouse

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Distribution warehouses are a critical part of a seamless supply chain. Un-automated, labour-intensive warehouses are responsible for a significant share of the large operational costs, and as such there may be opportunities for efficiency gains. Of the operations typically performed at a distribution warehouse, manually picking items to fulfil orders is one of the costliest. In particular, travelling between picking positions is very time-consuming. Therefore, minimizing travel times can help bringing cost down. This talk describes the collaboration with SONAE SR, a fashion and sports goods retailer, which aimed to improve the layout (selection of the best zone location), and zone storage assignment policy (where to locate each product in each zone) at its main warehouse to improve the order-picking performance by means of travelling time reduction. Our methodology simultaneously optimizes layout and storage assignment policy decisions by combining simulation with optimization and encompasses three phases. The first phase characterizes picking performance under different storage assignment policies and zones configurations through a simulation model. Phase two is a mixed integer optimization model which defines the overall warehouse layout by selecting a configuration and a storage assignment policy for each zone among the ones studied in the previous phase. Finally the model's optimized solution is tested under uncertainty in a final simulation step. This methodology was tested in the two warehouse areas: racks (pallet racks) and mezzanine (boxes shelves), using three months of operational data. The new layout and zones policy assignment defined by the methodology are estimated to improve picking performance by 15%. SONAE SR is nowadays implementing the suggested changes.