IEMS'18

9th Industrial Engineering and Management Symposium

The Impact of DEGI Research on Society

Auditório Infante D. Henrique

4th January 2018

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Abstracts Booklet of IEMS'18

$9^{\underline{\text{th}}}$ Industrial Engineering and Management Symposium: The Impact of DEGI Research on Society

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Acknowledgment 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:

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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

Welcome!

Eight years ago, more precisely on January 7, 2010, in the charming setting of "Casa do Infante", the first edition of the IEMS (Industrial Engineering and Management Symposium) was held. The symposium was the offspring of an idea of Prof. Bernardo Almada Lobo, who was challenged by the Executive Committee of the Department of Engineering and Industrial Management of FEUP (DEGI) to propose initiatives to promote applied research. The aim of the proposal was not only to encourage research addressing real problems of organizations, but also to make public the capabilities of DEGI outside the university. As now, it was assumed that contributing to Society was part of our culture and DNA. Thus, the first edition of the IEMS included a session on the university-business partnership issue (by Prof. Rui Guimarães, at the time Executive Director of COTEC Portugal) and another one on how to increase scientific productivity (by Prof. António Mendes Ferreira from FEUP). It was a promising start involving 60 participants. All eight previous editions of IEMS have adopted a format similar to the original. Meanwhile, everything improved substantially: the number of participants (120 in 2016, 107 in 2017, including many that do not belong to the FEUP universe), the quality of the presentations, the sharpness and the richness of the elevator pitches and, above all, the maturity and relevance of the research that is carried out. For those who, like me, attended the first edition of IEMS, those facts are undeniable and a cause of great satisfaction! Nevertheless, I am sure that this year the event will be even better. The IEMS'18 includes three sessions dedicated to the presentation of research projects, a period for the elevator pitches exhibition, and an End-to-End session. This symposium would not be possible without the contribution of the 23 researchers who submitted abstracts, whether or not they have been selected for full presentations. Many thanks to all of them. On behalf of DEGI, my deepest gratitude to the generous and talented students of the Doctoral Programme in Engineering and Industrial Management of FEUP who organized this year's edition. I warmly welcome all the attendees, being certain that it will be a fruitful journey. Enjoy the day!

The Director of DEGI
José António Sarsfield Cabral

Auditório Infante D. Henrique, Leça da Palmeira, January 4$^{\underline{\text{th}}}$, 2018

Information for Participants

Symposium Venue

The symposium will take place at Auditório Infante D. Henrique. This building belongs to APDL Port Authority of Douro and Leixões.

The venue information is detailed below:

- Address: Next to the entrance of the Marina de Leixões, Leça da Palmeira. $41°11'16.00''N$ $8°42'15.00''W$
- Tel.: +351 229 990 700
- Email: marketing@apdl.pt

Figure 1: *Exposition room.*

Figure 2: *Auditorium.*

There will be private parking available, but is also possible to park on the street.

When you arrive at the venue, please perform the check-in at the Exposition room, see Figure 1. Coffee breaks and lunch will be served at the Exposition room as well. Lunch is a courtesy of DEGI–FEUP and vegan meals will be available upon early request. All oral communications of IEMS'18 will occur at the *Auditorium*, see Figure 2.

Internet

There is Wi-Fi access in the building, with no password required.

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'18 website: `http://www.fe.up.pt/~degi/iems18`. During the breaks, the elevator pitches will also be displayed at the Exposition room. A bulletin containing thumbnails of the elevator pitches will be distributed to all participants. Each participant has **three votes**.

Program Schedule

Thursday, January 4th

Reception of the Participants: 8:30 – 8:55 (*Entrance - Exposition room*)

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

Morning Chair: Ana Simões

PhD Projects: 09:00 – 10:00 (*Auditorium*)

A.1 A sustainable energy system approach for wastewater treatment plants. Alda Henriques, Ana Camanho, Pedro Amorim

A.2 Root Cause Analysis: A Propositional Vs. Relational Approach. Eduardo Oliveira, Vera L. Miguéis, José Borges

A.3 A co-evolutionary matheuristic for the car rental capacity-pricing stochastic problem. Beatriz Brito Oliveira, Maria Antóia Carravilla, José Fernando Oliveira

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Coffee-Break: 10:00 – 10:30 (*Exposition Room*)

PhD Projects: 10:30 – 11:30 (*Auditorium*)

B.1 Supply Chain Risk Rating: A basal assessment framework derived from Complexity and Continuity. João Dias da Silva, Alcibíades Guedes

B.2 Retail Distribution to Brick-and-Mortar Stores. Sara Martins, Pedro Amorim, Bernardo Almada-Lobo

B.3 An information management approach for recovering from supply chain disruptions. Dario Messina, Ana Cristina Barros, António Lucas Soares, Aristides Matopoulos

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Break: 11:30 – 11:40 (*Auditorium*)

Elevator Pitches: 11:40 – 12:10 (*Auditorium*)

Fábio Neves-Moreira, Maria João Pires, Eric Costa, Sofia Cruz-Gomes, Xavier Andrade

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Lunch: 12:10 – 14:00 (*Exposition Room*)

Afternoon Chair: Luís Guimarães

End to End: 14:00 – 15:30 (*Auditorium*)

D.1 HS.Register - an audit-trail tool to respond to the General Data Protection Regulation.
From FEUP: Duarte Gonçalves-Ferreira
From HealthySystems/FMUP: Ricardo Cruz-Correia

D.2 Anda Project: Simplification and Improvement of the Andante system.
From FEUP: Marta Campos Ferreira
From Transportes Intermodais do Porto: João Marrana

D.3 The role of advanced nurse practitioners in achieving health gains and quality of care.
From FEUP: Mário Amorim Lopes
From Ordem dos Enfermeiros: To be confirmed

Break: 15:30 – 15:40 (*Auditorium*)

Elevator Pitches: 15:40 – 16:00 (*Auditorium*)

Parisa Sadeghi, Thomy Eko Saputro, Maria João Santos, Nicolau Santos

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Coffee-Break: 16:00 – 16:30 (*Exposition Room*)

PhD Projects: 16:30 – 17:30 (*Auditorium*)

E.1 A vehicle routing problem with multiple synchronisation constraints: application in the biomass supply chain.
Ricardo Soares, Alexandra Marques, Pedro Amorim

E.2 The use of Smart Grids as a strategy for climate change mitigation and adaptation. Débora São José, Nuno Fidalgo

E.3 Robust Supply Chain Design under Supplier Integration and Consolidation Uncertainty: an Aerospace Case-study. Nuno Falcão e Cunha, Thiam-Soon Gan, Bernardo Almada-Lobo, Pedro Amorim, Martin Grunow

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Break: 17:30 – 17:45 (*Auditorium*)

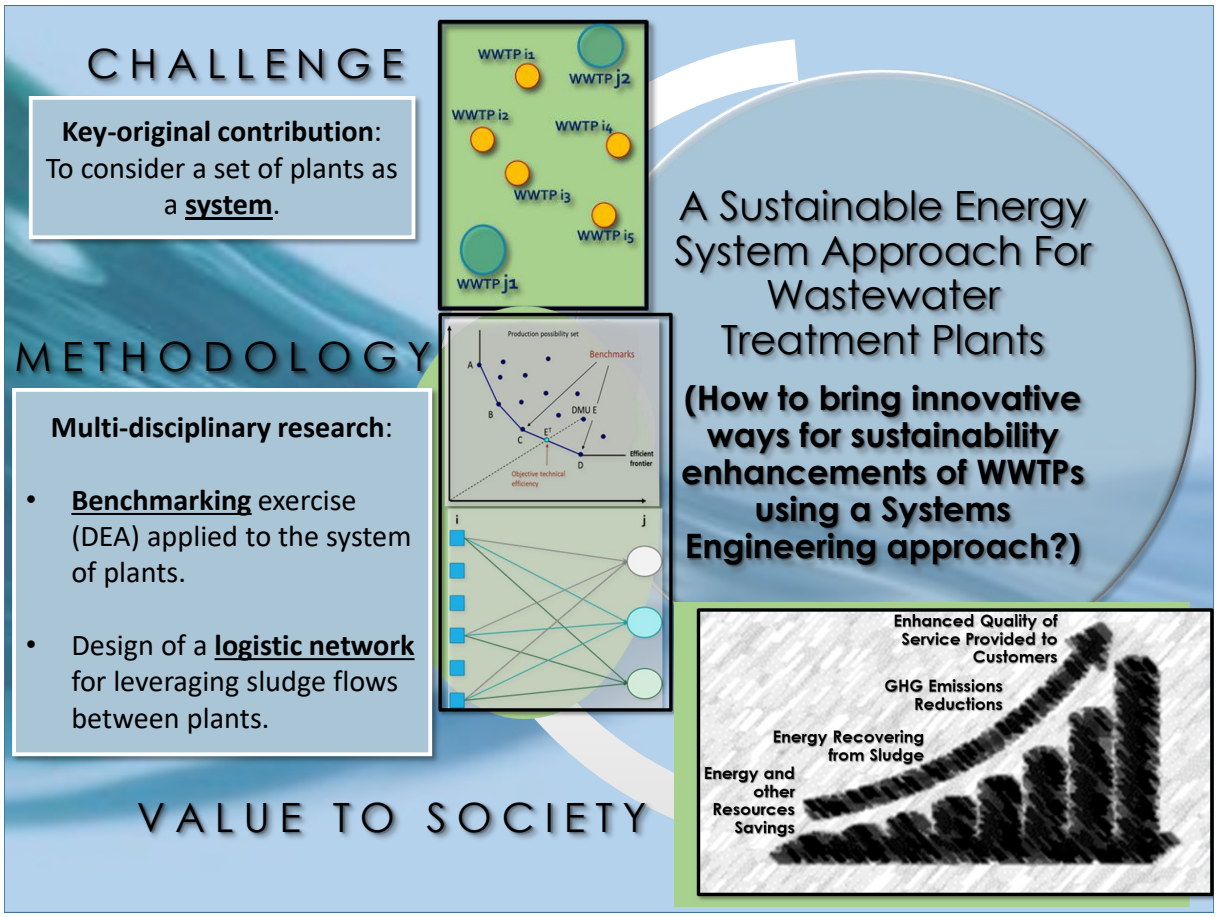
Award for the best elevator pitch and Closing Session: 17:45 (*Auditorium*)

Abstracts

A sustainable energy system approach for wastewater treatment plants

Alda Henriques*, Ana Camanho*, Pedro Amorim*

*INESC TEC and Faculty of Engineering, University of Porto



1 The Challenge

This abstract provides a summary of the doctoral research under progress, which is focused on improvements to the activity of wastewater treatment plants (WWTPs). A Portuguese company is used as a case-study. The WWTPs are the facilities where the wastewater is subject to several treatment processes, including physical separations and biological and chemical transformations. The wastewater treatment is accompanied by a continuous production of sludge that must be safely disposed in nature. The sludge resulting from the wastewater treatment has a very high energetic content, several times higher than the amount of energy that is necessary to spend during the wastewater treatment. Currently, the WWTPs are managed as individual assets, often ignoring potential interconnections among them that could enhance the efficiency of the system. In particular, there is still a high potential for energy recovery from sludge that can be exploited through the optimization of sludge flows among the wastewater treatment plants in system. Currently, only a small proportion of the sludge produced is used for energy recovery, as this process only occurs for the sludge produced within the plants with anaerobic digesters available.

Our challenge is to identify innovative ways to enhance the sustainability of the wastewater treatment plants using a Systems Engineering approach. This requires a multi-disciplinary research combining different management science techniques. The key original contribution of our research is to consider the set of plants as a system, rather than individual assets. This requires rethinking the system, implementing new procedures that can significantly improve performance without requiring infrastructural investments or increases in operational costs.

Our research contribution is twofold: (1) To develop a comprehensive management approach applicable to WWTPs. This approach should be generalisable and applicable to different contexts, enhancing the sustainability of the water sector worldwide; (2) The wastewater treatment industry involves the integration of the respective companies mission and its interactions with customers that is translated in the quality of service provided. Therefore, this research constitutes not only a practical application of a Systems Engineering approach that can contribute to enhancements in this research area, but also may provide useful results to enhancements in other sub-areas, particularly the Service Systems Engineering.

In terms of the results of this research, the increased understanding of the WWTPs system should provide benefits both for the company, its customers and regulatory authorities. Regarding the company, the benefits will include resource savings, that may be achieved through efficiency improvements based on the insigts gained from a quantitative benchmarking exercise. In addition, the research will provide guidance for the improvement of biogas production, leading to increased revenues through the development of a logistics network for leveraging sludge flows between plants with and without anaerobic digesters. Both results require a system-wide vision of the plants operation and sludge management. Regarding the customers, the benefits will be translated into an enhanced quality of service provided by the company. Finally, we expect to develop innovative approaches to monitor performance in the water sector, which can increase the effectiveness of the regulator (ERSAR).

To ensure the applicability of the framework developed in a real-world setting, it was selected a case study consisting of a Portuguese water company that operates sixty WWTPs (Águas do Centro Litoral, AdCL). This company treats 12% of the volume of wastewater treated at a national level, according to the regulator database for the year 2015.

2 The Methodology

Data Envelopment Analysis (DEA) technique is used for the quantitative benchmarking analysis of the set of WWTPs. This technique is widely recognized to be well adjusted to the context of WWTPs performance assessment. A key features of this technique that represents an advantage in relation to alternative techniques is its non-parametric frontier nature. The non-parametric nature allows the evaluation of very complex production processes that cannot be accurately represented recurring to parametric functional forms. The frontier nature allows the identification of best practices among a set of observations, as well as the specification of realistic targets for potential efficiency improvements for plants considered inefficient.

For the maximization of biogas production, we selected an optimization procedure based on mixed integer linear programming. This technique is the most suitable for the design of a logistic network to leverage the sludge management optimization underlying the biogas production. The logistic network design takes into consideration several features: (i) the capacity slack in the plants with anaerobic digestion, which is available to process sludge from other plants; (ii) the technical aspects underlying the biological process used for sludge treatment - the anaerobic digestion process (AD), and the energy content of the sludge transported between plants.

3 The value to Society

The management framework proposed can contribute to the maximization of positive externalities associated with the wastewater treatment process. These positive effects include three main components: (1) The total amount of energy that is saved from the combination of efficiency gains and through the new

operational practices proposed for sludge management; (2) The total amount of indirect greenhouse gas that are not emitted due to the energy savings; (3) The total amount of the additional biogas produced through the new sludge management approach, which can be used for electricity and heat production (with a renewable source).

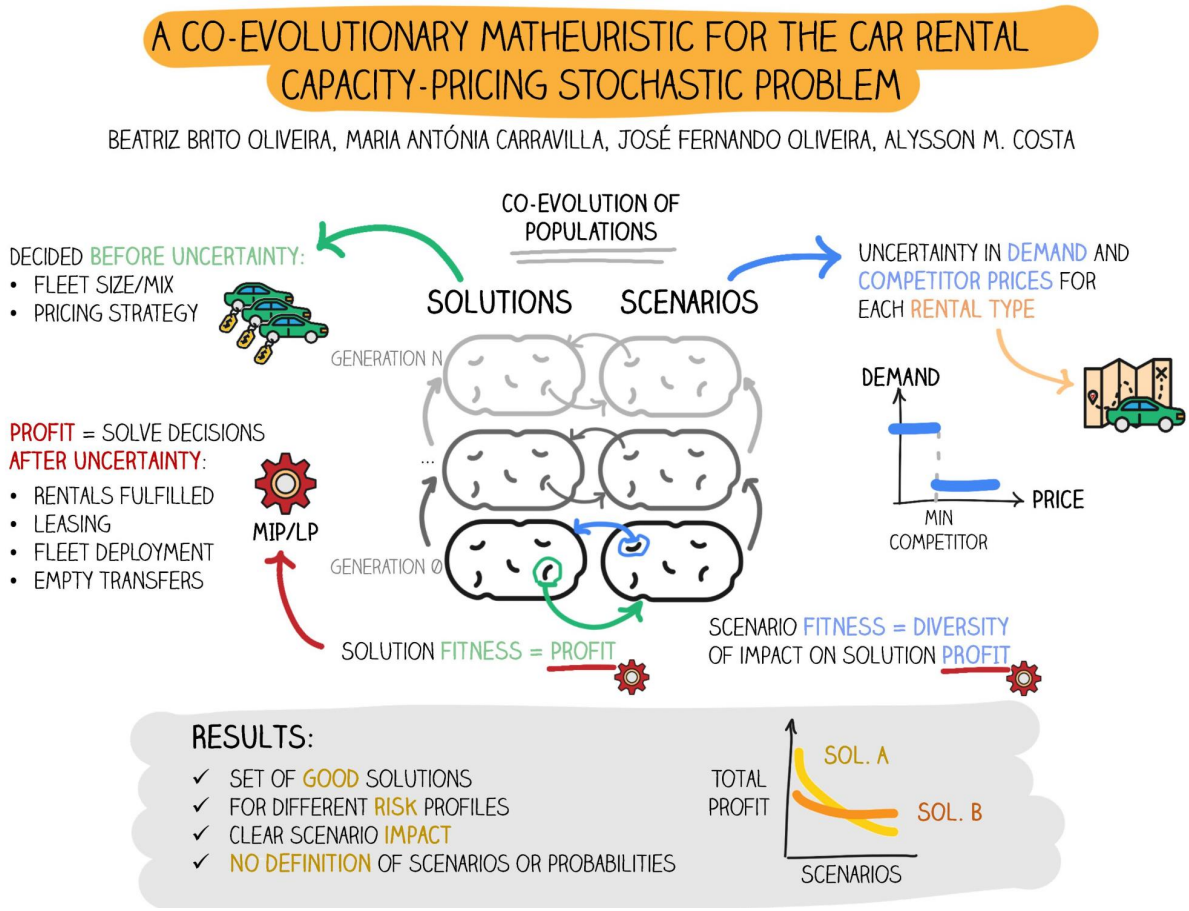
In terms of the results of the benchmarking approach, the target for potential improvement in terms of energy savings is 5315 MWh/year. This corresponds to a reduction of 31% in relation to the current levels of energy consumption, representing a 907 ton reduction of carbon dioxide (CO_2) emissions (according to the IEA composite electricity/heat factor for Portugal, obtained for the year of 2011 ($0.38\ kgCO_2/kWh$)). These benchmarking results were obtained for a set of 38 WWTPs of AdCL based on the data provided by the company for the year 2015.

In terms of the new sludge management approach, the logistic network model was developed at the tactical level. It allows to identify the WWTPs that shall enter the network system, and determine the typical amount of sludge that should be daily transported between the plants selected. The objective is to maximize the total profit obtained through the monetary value accrued from the electricity produced through the biogas recovered from the sludge, as well as the electricity saved by the operational adjustments proposed for sludge management. All logistics costs and all the energy from biogas that is necessary to maintain the AD process were also taken into account. The critical aspects of this modelling approach is to understand the constraints associated both to the sludge management at the export plants and to the introduction of additional amounts of sludge in the available capacity of anaerobic digesters. The computation of sludge demand at the receiving facilities, given all the optimized operating conditions, is also a modelling challenge. The results obtained so far are still preliminary and further improvements are expected to be obtained during the doctoral research. These will be accomplished with the analysis of new data recently provided by the company. All results obtained are validated in meetings with stakeholders of AdCL, with deep technical knowledge on the topic of sludge management and AD processes.

A co-evolutionary matheuristic for the car rental capacity-pricing stochastic problem

Beatriz Brito Oliveira*, Maria Antónia Carravilla*,
José Fernando Oliveira*, Alysson M. Costa‡

* *INESC TEC and Faculty of Engineering, University of Porto,* ‡ *School of Mathematics and Statistics, The University of Melbourne*



1 The Challenge

When planning a selling season, a car rental company must decide on the fleet size and mix, i.e. the number of vehicles of each group, or capacity, it will have to meet demand throughout the season and rental locations. The products commercialized are the different types of rentals, which are characterized by start and end time and location, and vehicle group required. The demand for these products is uncertain and highly price-sensitive. With the exception of market-leading companies that benefit from a strong brand effect, it can be assumed that, for a given rental type, it is the lowest price in the market that attracts most of its demand, leaving a residual slice of the market for the remaining companies. Therefore, the prices charged by a company are connected with and should influence the capacity decisions.

Since a company deals with a myriad of different rental types with independent demand and pricing, for the duration of the season it must also decide on the deployment of the fleet throughout space (rental

stations) and time (selling season horizon) to meet demand. This deployment can be achieved by empty transfers of the vehicles or by rentals that start and end in different locations. Moreover, if needed, the company may also temporarily lease vehicles at a higher cost in order to face peeks of demand.

Two main decisions must be made before the uncertainty on overall demand levels and competitor prices is revealed: fleet capacity and general pricing levels for each rental type. After the season begins, the prices charged by the competitors for each rental type are revealed, as well as two different levels of demand: a higher level if the company's price is the lowest in the market and a residual level otherwise. Afterwards, the company decides on recourse decisions, such as fleet deployment or exceptional leasing, in order to define what rentals it will fulfill.

The goal of this work is to provide decision-makers with profitable solutions to the first stage decisions – capacity and pricing –, describing their ability to deal with the different realizations of uncertainty, represented by scenarios. Due to this more strategic setting, mainly focused on seasonal fleet management, overall and general levels of demand and prices are considered, and more operational "online" pricing decisions (such as updating prices throughout the season) are excluded from the scope.

2 The Methodology

The methodology developed is based on a co-evolutionary genetic algorithm, where parallel populations of solutions and scenarios co-evolve, depending on each other for the fitness evaluation of their individuals. Figure 1 represents the general structure of this parallel co-evolution. On the one hand, this method aims at obtaining a representative and diverse population of scenarios, in relation to the impact they have on the population of solutions. For this, diversity measures inspired by recent developments in feature-based diversity optimization for instance generation are applied. On the other hand, solutions converge to well-performing first-stage decisions based on three different decision-making profiles that use optimist, pessimist and Laplace criteria to assess the performance of a solution against the population of scenarios.

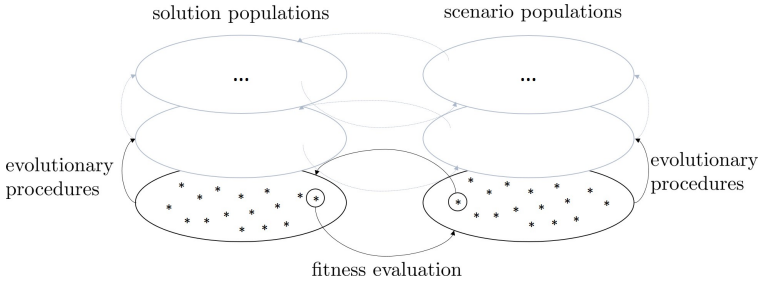


Figure 1: Structure of the co-evolutionary algorithm.

Solutions herein represent the first-stage decisions of the stochastic problem: capacity and pricing. To assess a solution, for each scenario the optimal value of the recourse problem should be computed, i.e. deciding what are the deployment, leasing and rental fulfillment decisions that result on the best profit. The methodology used is considered a matheuristic because the linear program that results from relaxing the integrality constraints on the second-stage sub-problem is solved to assess the total profit obtained for each <solution, scenario> pair.

As mentioned previously, solution fitness is computed using three different criteria. With an optimist criterion, solution fitness is the best value achieved throughout the scenarios. Using a pessimist criterion, it is the worst value achieved and solutions converge towards robust performances on the worst-case. With the Laplace criterion, the simple (non-weighted) average of values achieved in all scenarios is considered.

In this problem, the only information available on the uncertain parameters is the lower and upper bounds of the values they can take. A scenario represents a possible combination of realizations for the uncertain parameters, within these bounds. The goal is to obtain diverse scenario population. This diversity is related with the impact of the scenarios on the solution population, i.e. on the total profit obtained by the solutions against the different scenarios. Therefore, the fitness of an individual scenario translates its contribution to the population diversity and is based on the distance to the nearest neighbors, in terms

of difference in total profit obtained by the solutions. With this, scenarios that push the extreme values obtained and scenarios that "fill in gaps" within this space are favored.

3 The value to Society

This study presents not only an innovative approach to deal with the car rental problem at hand, but also methodological contributions that can be applied beyond this scope.

Firstly, this method does not require the decision-maker to define the scenarios or probabilities associated with them, but only to establish upper and lower bounds for the uncertain parameters. The scenarios are generated and evolve alongside the solutions, and are fine-tuned to be representative and diverse in relation to these solutions. This is of particular interest in practical applications where the number of uncertain parameters is large and the explicit definition of uncertainty scenarios is difficult to obtain.

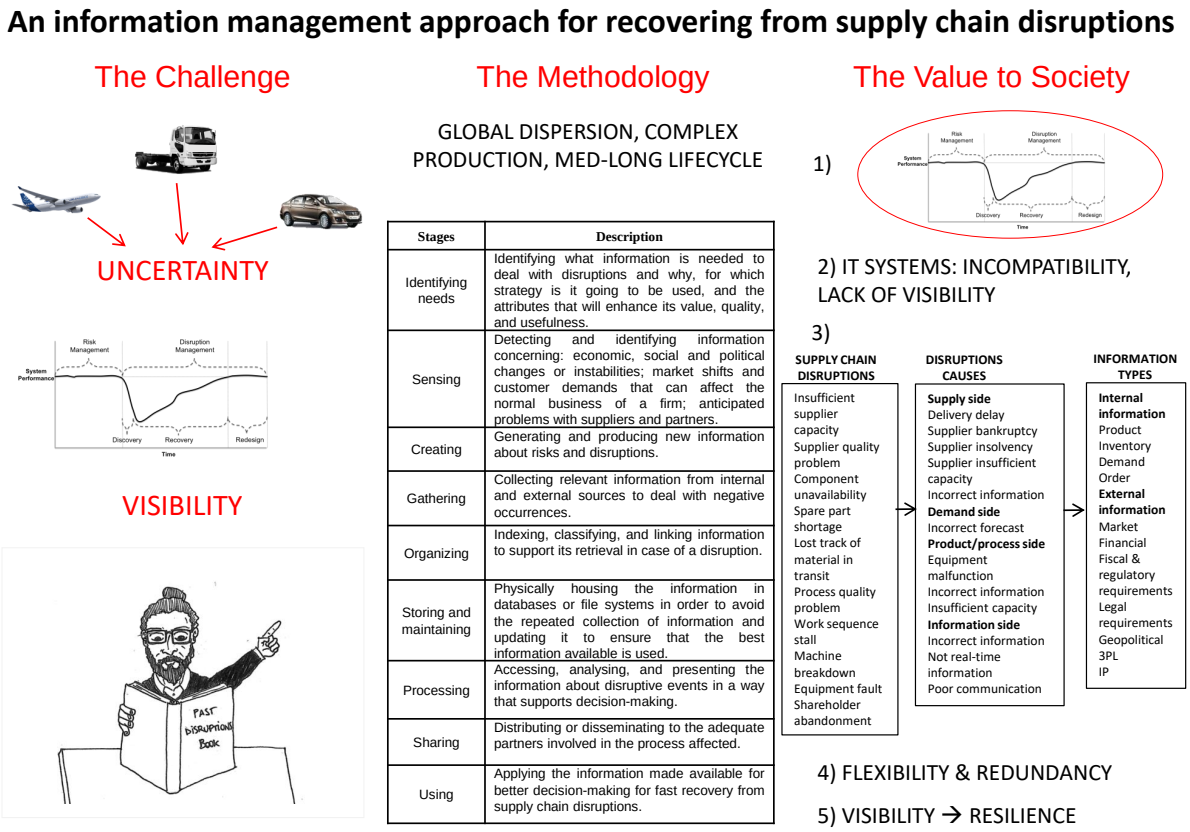
Secondly, this method provides the decision-maker with a set of possible solutions, clearly associated with the impact that the different scenarios have on them. For example, a more risk-adverse decision-maker could prefer a solution that does not achieve a very high profit, but has a constant behavior, more independent of the scenarios.

In the future, the method and model presented could be extended towards a more tactical (possibly weekly) scope, in order to develop a decision-making support tool for the decisions not considered here. In the car rental problem, this could mean decisions regarding multi-stage-oriented pricing and deployment actions. Moreover, the methodology can be extended and should be tested in other industry applications that can be represented by a two-stage stochastic model and whose scenarios are not entirely known.

An information management approach for recovering from supply chain disruptions

Dario Messina*, Ana Cristina Barros†, António Lucas Soares*, Aristides Matopoulos‡

* *INESC TEC and Faculty of Engineering, University of Porto,* † *INESC TEC, Portugal,* ‡ *Aston University, UK*



Stages	Description
Identifying needs	Identifying what information is needed to deal with disruptions and why, for which strategy is it going to be used, and the attributes that will enhance its value, quality, and usefulness.
Sensing	Detecting and identifying information concerning: economic, social and political changes or instabilities; market shifts and customer demands that can affect the normal business of a firm; anticipated problems with suppliers and partners.
Creating	Generating and producing new information about risks and disruptions.
Gathering	Collecting relevant information from internal and external sources to deal with negative occurrences.
Organizing	Indexing, classifying, and linking information to support its retrieval in case of a disruption.
Storing and maintaining	Physically housing the information in databases or file systems in order to avoid the repeated collection of information and updating it to ensure that the best information available is used.
Processing	Accessing, analysing, and presenting the information about disruptive events in a way that supports decision-making.
Sharing	Distributing or disseminating to the adequate partners involved in the process affected.
Using	Applying the information made available for better decision-making for fast recovery from supply chain disruptions.

1 The Challenge

With uncertainty becoming the new norm for businesses, all supply chains are susceptible to disruptions. Therefore, studying how firms are capitalising from previous disruptions to refine mitigation strategies is an important step towards understanding how to shorten the recovery time during future disruptions.
A risk mitigation strategy that has received substantial attention from researchers and practitioners is the increase of supply chain visibility. Supply chain visibility is defined as the "capability of a supply chain player to have access to or to provide the required timely information/knowledge about the entities involved in the supply chain from/to relevant supply chain partners for better decision support". Companies achieve supply chain visibility by using information systems to gather, organize and analyse supply chain data. Consequently, this paper aims at identifying and analysing the actions taken by supply-chain members during and after disruptive events in order to improve the risk management process. The research question leading this paper is: "How does information management enhance visibility towards

increasing supply chain resilience?". Regarding the theoretical approach, information processing theory is used as a lens of analysis to explore the adoption of the information management model in dealing with supply chain disruption, in real settings.

2 The Methodology

Due to the exploratory nature of the work, case study research is an appropriate research method to be used. Three case studies were carried out with vehicle assemblers of aircraft wings, trucks, and cars. The vehicle assembly context was chosen for its characteristics of global dispersion of partners, complex production, medium-long lifecycle of products, and high uncertainty.

Stages	Description
Identifying needs	Identifying what information is needed to deal with disruptions and why, for which strategy is it going to be used, and the attributes that will enhance its value, quality, and usefulness.
Sensing	Detecting and identifying information concerning: economic, social and political changes or instabilities; market shifts and customer demands that can affect the normal business of a firm; anticipated problems with suppliers and partners.
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Figure 1: Information Management Model for Supply Chain Disruption Management

As we are studying how companies use information to gain visibility over supply, demand, information, and product management processes, the interviewee profiles used were precisely Supply, Demand or Logistics, Production, and Information System Managers. Relatively to the research logic selection, information processing theory is used here for theory extension. The unit of analysis is the information management model (see Figure 1) used by companies to recover from disruptions. Data collection is carried out by means of semi-structured interviews. A total of 17 interviews were conducted, at firm level. All the interviews were recorded, transcribed and then coded with the support of specific software (MAXQDA).

3 The value to Society

This research has generated several important discussions for both the community of practitioners and the community of researchers. The first contribution results from the analysis of disruptions occurring at operational level to propose a conceptual framework (Figure 2) aiming at supporting decision makers in the recovery from day-to-day disruptive events. The framework begins with the detection of a disruption and investigation about the causes that lead to disruption. Once the disruption cause has been detected, the decision maker will needs visibility over a set of information types, based on past occurrences, to implement the recovery strategy. A practical example retrieved from the case is the following. One of the firm detected the unavailability of a final product, and identified a supplier delay as cause of the disruption. In order for the decision maker speeding up the following processes and recover for the

time lost, the IT system should provide visibility over product, inventory, legal and third part logistics information types. Secondly, the analysis of information systems in real settings showed that most of these systems present incompatibility among them and are still lagging in providing visibility. This fact was confirmed by the adoption of several complementary tools such as email and telephone that neither allow tracking the shared information nor allow its integration in the main system. The third contribution is related to the extension of information processing theory, into a less explored research field such as supply chain disruption management, by presenting an information management model applied to disruption management.

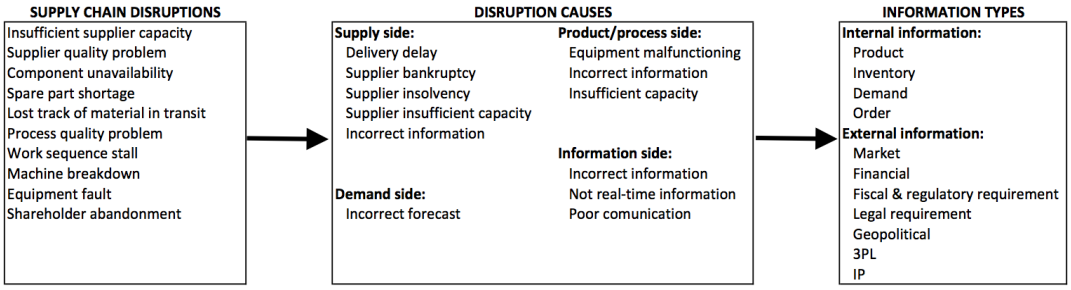


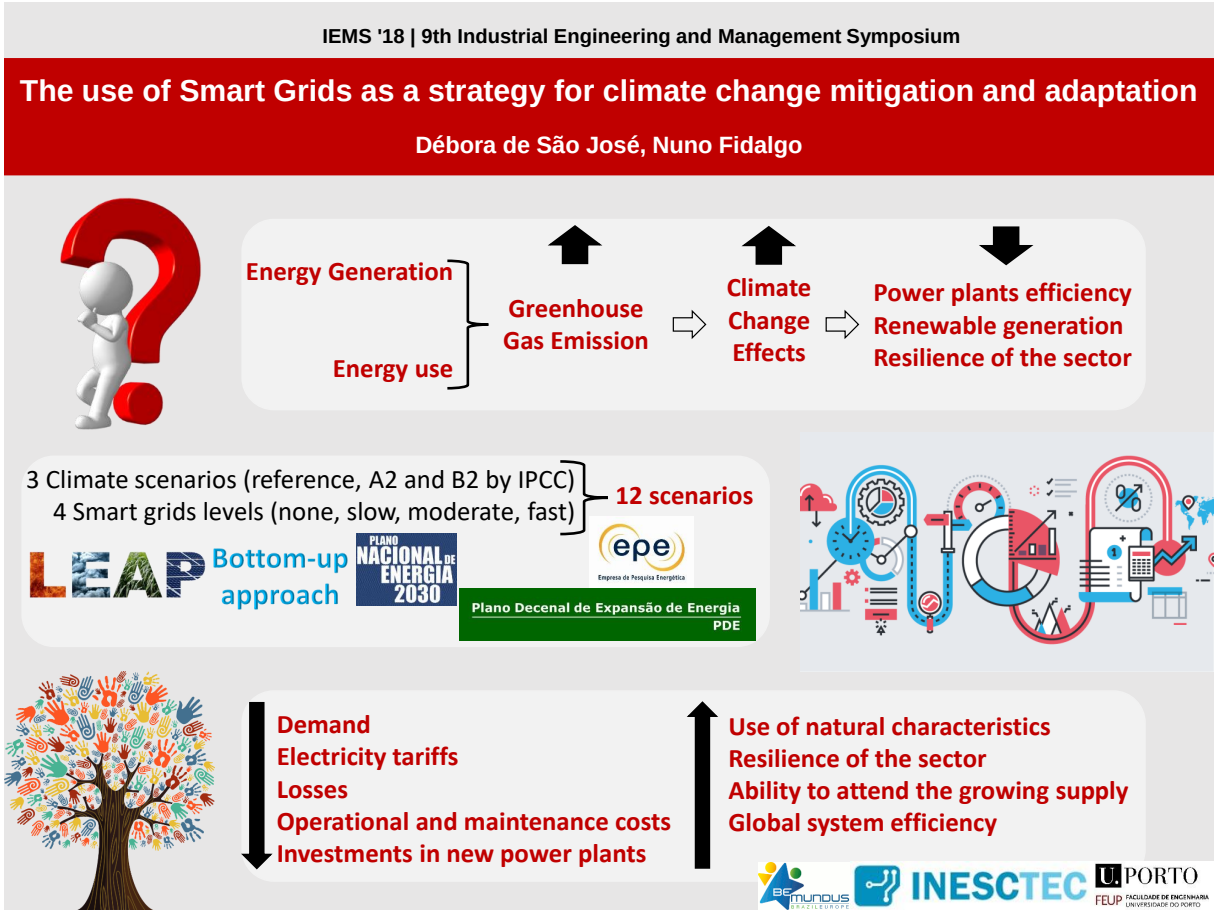
Figure 2: Conceptual model according with within- and cross-case analyses

The cases confirmed the adoption of practices belonging to two strategies of risk management, namely flexibility and redundancy. The verification of our information management model, allows to take into account the different perspectives and needs of the users in approaching supply chain disruption problems. Also, model validation will be made through workshops with the same firms involved in the case study. A better understanding of how firms may manage disruptions and facilitate recovery is vital for supply chain risk management. Practical implications were retrieved from the analysis of the cases, that confirm the increasing need of visibility in order to enhance resilience.

The use of Smart Grids as a strategy for climate change mitigation and adaptation

Débora de São José*, Nuno Fidalgo*

* *INESC TEC and Faculty of Engineering, University of Porto*



1 The Challenge

Climate change is a much-commented topic as its effects are expected to affect natural and human systems. Issues such as vulnerability, adaptation and mitigation has been taken by several sectors, among which the energy sector. In the world, the energy sector is a major contributor for the climatic change phenomenon, although it is also one of the most affected by it, especially the renewable sources. In fact, the energy usage often results in greenhouse gases emissions, affecting climate in such way that deteriorates the potential of renewables generation. As less renewables means more emissions, this cycle needs to be interrupted.

Smart Grids technology could help on mitigation and adaptation of the Brazilian electricity sector to climate change, as it is, according to the International Energy Agency, an electricity networks that use digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. These features would allow the

monitoring and control of the entire electric power system, and consequently, more efficient networks use and deeper integration of renewables.

2 The Methodology

Twelve scenarios were created to simulate the sector in 2030, resulting from the combination of three climate hypothesis and four power system states. The climate cases comprise a reference scenario and two scenarios with climate impacts based on the Intergovernmental Panel on Climate Change special report emissions scenarios A2 and B2: (1) A2 scenario represents a very heterogeneous world, with self-reliance and preservation of local identities, fertility patterns across regions converge very slowly, continuously increasing global population, economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines; (2) B2 scenario represents a emphasis is on local solutions to economic, social, and environmental sustainability, continuously increasing global population at a rate lower than A2, intermediate levels of economic development, less rapid and more diverse technological change than in other storylines, oriented toward environmental protection and social equity, focuses on local and regional levels.

The four power system cases involve, one without smart grids, and three with different levels of smart grids technologies penetration in the Brazilian grid, namely slow, moderate and fast. The baseline scenario was developed assuming that current development trends continue, and no actions are undertaken to explicitly reduce the greenhouse gas emissions.

The estimation of the installed capacity evolution took into consideration the projections presented by national energy plan 2030 and the annual decennial energy expansion plan's projections and the real values, i.e., a comparison between what was planned and the observed capacity until 2015.

The projections for the power sector in 2030 were based on a bottom-up approach, which was preferred as it provides a disaggregated picture of energy demand and supply, and allows for estimation of potential gains in efficiency from specific technologies and/or the potential for substitution of less carbon intensive technologies, with the use of an energy accounting model, LEAP (Long-range Energy Alternatives Planning System) developed at the Stockholm Environment Institute as LEAP has become the de facto standard for countries undertaking integrated resource planning and greenhouse gas mitigation assessments, especially in the developing world.

This research adopted the characteristic three-step structure: (1) evaluation of greenhouse gas reduction and carbon sequestration options; (2) development of a baseline scenario; and (3) development of greenhouse gas reduction or mitigation scenarios, including an estimation of scenario costs and greenhouse gas mitigation potential.

For this research, it was decided to use conservative values for smart grid's benefits, following the assumptions adopted by the Working Group on Smart Grids in Brazil.

3 The value to Society

The analysis of the simulation outcomes shows that the best mitigation and adaptation results came from the B2 group of scenarios, which represented not only the changes in climate but also the changes in society (awareness about environmental issues, use of equipment that is more efficient, sustainable growth, global solutions, among others). Smart grid would also help to reduce electricity tariffs by increasing the ability of the grid to take the most of Brazilian natural characteristics that gives the country great winds, insolation and water, preparing the grid to work with intermittent sources.

The tariffs could also be reduced by reducing the losses and smart grids can help with that, a 20 percent reduction in total losses could be expected in some of the analyzed scenarios.

Finally, smart grids also proved itself as able to reduce the operational and maintenance costs and the

investments in new power plants after 2030. In the scenario without climate change, the investment in new power plants could be almost 40 percent less with smart grids when comparing to the investment needed without it, and in the most optimistic scenario, B2, this investment with smart grids could be 60 percent less than would be in the B2 scenario without smart grids.

Root Cause Analysis: A Propositional Vs. Relational Approach

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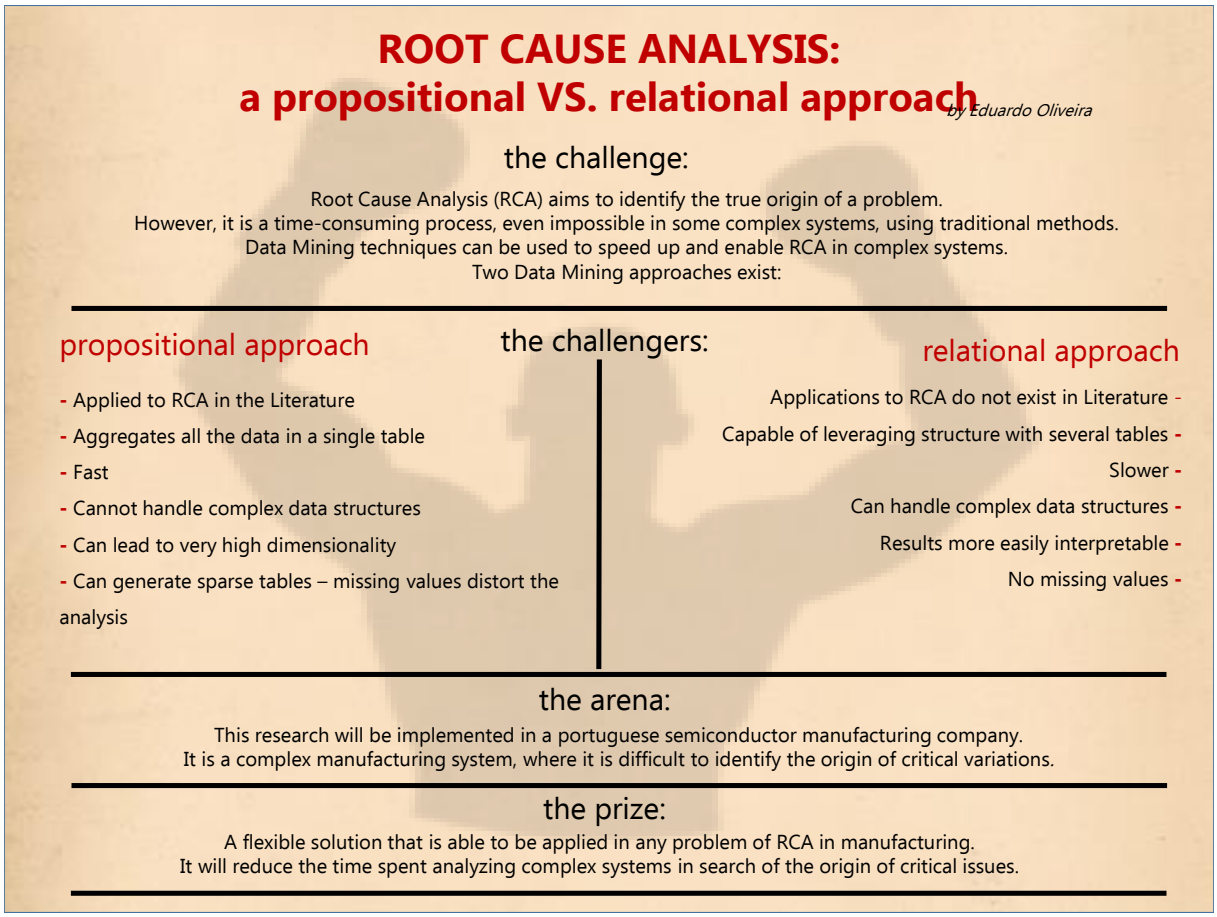

1 The Challenge

In many activities, whenever there is a problem, it is important to completely understand the problem in order to not only fix it, but also to find ways of preventing it from happening again. By understanding the underlying, or root cause behind a problem, prevention of future issues and improvements can be devised and implemented. Root Cause Analysis (RCA) can then be defined as a process of analysis of an event or series of events, in order to identify the initial mechanism (or the origin) that caused the event(s) of interest to happen.

RCA has an investigative nature. In a manufacturing context, RCA has traditionally been performed using several quality management tools, such as Ishikawa diagrams or the 5-whys. This means to investigate each problem independently, by using the available information to determine the sequence of events that lead to the problem. One can even compare RCA to the job of a detective on a crime scene. Therefore, RCA is a time-consuming and costly procedure. However, it is indispensable, as it is the first

step for true improvement in processes and organizations. One cannot improve if one does not know where the error lies.

RCA is facing new challenges due to the ever increasing complexity of manufacturing, specially in high-tech processes, such as semiconductor manufacturing. The more complex such systems become, the harder it becomes to identify the point of origin of a problem, as we have to deal with more intricate and multi-variate mechanisms. A possible solution is to use new developments in computer science, namely machine learning and Data Mining (DM) techniques, to help see trough these complex mechanisms, and narrow down and identify the possible root causes of a problem.

The objective of this work is to study the different alternative ways DM techniques can be used to tackle the problem of RCA.

This research will be done in the context of a case study on a portuguese semiconductor packaging factory, Amkor Portugal. The company specializes in wafer-level packaging, which is a high-tech and complex manufacturing process. Given its complexity, it is difficult to identify the origin of variations in production levels and/or quality. Another objective of this study is to develop a solution that will be able to identify the root causes of these variations, and possibly predict them. Examples of such variations are the increase of false positives in automated inspection steps, or the increase in failures in intermediate stages of production.

2 The Methodology

A literature review on the topic identified three main types of algorithms applied to tackle the problem of RCA: Rule-based Classification, Model-based Classification, and Association Rules. The first two types of algorithms aim at developing a predictive model for the anomalous situation(s). Then, the most important variables used in the models (rule list or rule tree) generated by the algorithm are identified as root causes. In rule-based classification it corresponds to the attributes used in the rules, and in model-based classification it corresponds to the attributes with higher coefficients in the models. On the other hand, association rules methods create rules by trying to identify frequent occurrences of attribute values in the events of interest.

It can be seen that these types of algorithms have more emphasis on the interpretability of the extracted knowledge than on their predictive power. This is due to the nature of the problem, as these algorithms aid the investigation performed by the human expert by identifying possible root causes, that then have to be verified by the expert and/or the operational staff. This requirement of clear communication precludes the use of "black-box" algorithms.

All the mentioned types of algorithms are *propositional*. This means that they require the data to be stored in a single table, with attribute-value pairs in the columns. Each instance (row in a table) can be considered as an array of attribute-value pairs. This is not problematic for problems that are not very complex, in the sense that the structure of the problem allows for the construction of a table with a reasonable amount of columns. Yet, the increasing complexity of the problems is the main reason for the use of DM techniques in RCA.

Preliminary studies revealed that modeling the problem following a propositional approach leads to a very sparse table, i.e., a table with many columns and a high number of missing values. These missing values appear due to the fact that, in a propositional approach, the table must have a column for every possible attribute. The number of attributes can explode in the presence of complex structures. For example, consider a manufacturing process where a product can go through several stages. The number of stages varies with the type of product, or even with the presence or not of rework. As such, the number of columns a table must have in a propositional approach has to consider that the product can go through all stages of production. That may not be reasonable since it unnecessarily enlarges the table, generating a large number of missing values, one for each time a product does not go through a specific stage. This leads to increased computation time, more complex and harder to interpret models, and introduction of undesirable bias.

However, there exists an alternative to propositional approaches that aims at overcoming this problem. *Relational* approaches accept the use of multiple tables. In fact, they use the structure of relational databases (hence the name) in order to identify richer knowledge than that which could be possible with a propositional approach. Relational mining approaches use logic or graphs to represent complex structures, and relational DM algorithms aim at extracting meaningful patterns and make predictions based on these powerful forms of representation. This has two main advantages:

- First, it makes the results more easily interpretable
- Second, one does not have to worry about missing values distorting the analysis, as for each instance, only the relevant attributes are selected at each time.

We can consider as a third advantage the fact that this type of approach allows the use of background knowledge in order to reduce the space of possible solutions, leading to a more time-efficient search, and ensure that the proposed solutions are valid.

The main methods based on this approach are grouped into two categories: Inductive Logic Programming (ILP) and Graph Mining. These have as outputs rules or queries which are highly interpretable. In addition, the outputted rules are not restricted to propositional logic, but also encompass first-order logic (also known as predicate logic). Propositional logic simply checks if a certain condition occurs (e.g., if the product went through stage 12 or stage 14, then the product is faulty), while first-order logic enables rules that can consider relationships between objects (e.g., for any product A and B, if product A is faulty, and product B has the same cycle time as A, then product B is faulty).

Relational approaches have not been used in previous works in the literature addressing RCA. Given the reasons stated above, a more refined goal of this study is to investigate the use of relational approaches to RCA, and to compare them with the results obtained from propositional approaches. These approaches will be evaluated by their capacity of correctly identifying the root cause. The validation of the root cause detected is performed by experts. This underlines the importance of the case study for this research, as it enables the access to the experts required for the validation.

3 The Value to Society

This study hopes to bring forth a flexible solution that is able to be applied in any problem of root cause analysis, independent of the field of application, but it is ultimately interested in the improvements it can lead in manufacturing.

This study adds value by creating a solution that reduces the time spent analyzing complex systems in search of the origin of critical issues. This will increase the productivity of the responsibles for control and improvement, also leading to an increase in reaction speed throughout the factory, making it more flexible and agile. In complex manufacturing systems, it may even enable RCA, as an analysis using previously existing methods would be too time-consuming.

Industrial business associations supporting the internationalisation of SMEs by using digital platforms

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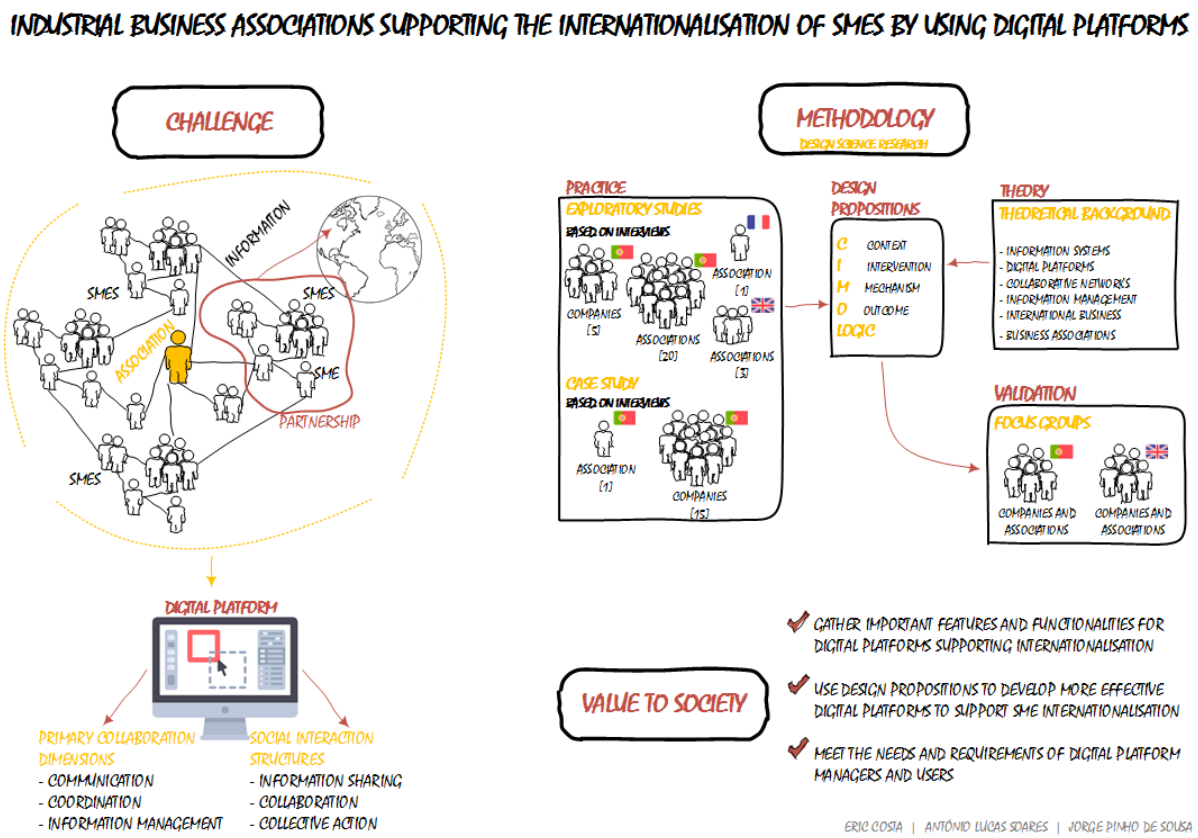

1 The Challenge

The digital economy is fundamentally creating disruptions in traditional industries and in global markets. Business models and traditional value chains are increasingly challenged as digitally conducted activities and services allow for greater availability, shorter delivery times, faster time-to-market, and lower transaction costs. This current situation can be translated into opportunities for lower overall costs, allowing smaller companies to compete with well-established companies and brands. At the same time, customers expectations become more demanding, increasing the competition across all business sectors.

Industrial business associations (IBAs) are already facing challenges to cope with all the transformations that are occurring in business markets. These difficulties are mainly related with problems of low membership and high opting out, instability over time, and inequalities due to the existence of associations of different types or sizes of businesses. These institutional entities will need to follow the current

digital trends in the industry to satisfy the ever growing demands of their associate small and medium enterprises (SMEs). A particular challenge can happen in supporting their internationalisation processes and international trade activities, processes that require different types of information and resources for establishing collaborations or for making decisions to enter into foreign markets.

Digital platforms are transforming different types of businesses across all markets, demonstrated by the rapid dominance of platform businesses like Facebook, Uber and Airbnb, over traditional industries. Digital platforms have become important for the activities of organisations, facilitating the communication inside work groups, supporting online communities, creating and managing information and knowledge, and allowing the establishment of collaborations. An IBA might use a digital platform to improve the internationalisation support provided to their associate SMEs, as well as to keep up with the current technological trends of markets. We believe that such transition to technology is crucial for the survival of IBAs, as it can avoid the loss of more associates, or even prevent the worst scenario of the services of the IBAs to no longer make sense for companies. However, the current challenge is on extending our understanding on how and whether technology is suitable and viable for supporting SME internationalisation and collaboration. In addition, there is still a lack of understanding on how organisations can effectively design digital platforms and on the effect of the use of digital platforms on management processes.

2 The Methodology

One of the aims of this doctoral project is to study the use of digital platforms to support SME internationalisation in the context of IBAs. So far, we have obtained the following findings:

Interviews with 5 industrial companies to understand their perspective about the use of digital platforms for supporting their internationalisation activities
The information management role of IBAs can be improved to better meet the internationalisation needs of members, with improved information organisation, more effective information dissemination, promoting information sharing among the members, and improved information quality.

Interviews with 20 IBAs in Portugal to extend the previous study, but also to increase our understanding on the current activities and the use of institutional network resources to support and facilitate internationalisation processes of SMEs
SMEs can benefit from the institutional network resources and support of IBAs to start or continue their internationalisation strategy. Such institutional network support by IBAs is provided through: promotional activities; counselling, training, and technical and legal support; information sharing; and cooperation with other institutional entities.

Interviews with 3 IBAs in the UK and 1 IBA in France to increase the validity of our findings
We have obtained an understanding of the current scenario of IBAs in different countries, allowing to add new knowledge about the internationalisation service provision by IBAs.

Analyse the perception of the 20 IBAs in Portugal, together with the 4 IBAs from the UK and France, regarding the use of digital platforms to improve the support to the internationalisation processes of their associate SMEs
Most of the IBAs are not using technology, such as digital platforms, to support the activities of their members. A communication using the email and the dissemination of information through their websites are still the basic technological channels typically used. In addition, we have obtained a rich set of requirements and features considered by the 24 IBAs, divided by different categories: Information; Collaboration; Communication; Other requirements; and Other features.

Study and evaluate current digital platforms that are being used by IBAs to support SME internationalisation
We have identified 9 digital platforms used by IBAs to support the international trade activities of SMEs, by describing their main objectives and features. However, the existing offer of digital platforms

are mainly for information dissemination, lacking to meet important requirements for the creation of effective collaborative networks or for enhancing social interaction structures of online communities.

Therefore, we have now a rich set of needs, requirements, and features for digital platforms supporting SME internationalisation, based on the perspective from potential users (SMEs) and managers (IBAs). We also have knowledge about the current offer in markets and the respective capabilities for supporting international trade activities of companies. By using all these findings, the next step will be to propose and validate a design theory, in the form of design propositions, for designing effective collaborative digital platforms, managed by IBAs, for supporting internationalisation processes of SMEs. This will be achieved by balancing theoretical knowledge on digital platforms and collaborative networks, with additional practical knowledge resulting from multiple case studies and focus groups in Portugal and in the UK, for designing and evaluating the design propositions. The purpose of design propositions is to obtain prescriptive knowledge, following the so-called CIMO-logic. CIMO-logic allows to obtain a systematic structure for the propositions, combining problematic Contexts with certain Intervention types to deliver specific Outcomes, following generative Mechanisms. Therefore, design principles that are formulated according to CIMO-logic indicate what to do, in which situations, to produce what effect, and offer understanding of why this happens.

3 The value to Society

The design propositions could be used by digital platform designers and by IBAs in general, to design and obtain more effective digital platforms that can meet the specific needs of users and managers, always having in consideration the main problems and difficulties of its implementation. By effective digital platforms we mean digital platforms that can offer primary collaboration mechanisms for establishing effective collaborative networks, as well as support different types of social interaction structures. In terms of contributions to theory, the design propositions could bring new knowledge on how organisations can effectively design digital platforms supporting online communities and collaborative networks, having the specific context of internationalisation.

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On Improving Supply Chain Performance Through Integrated Vehicle Routing

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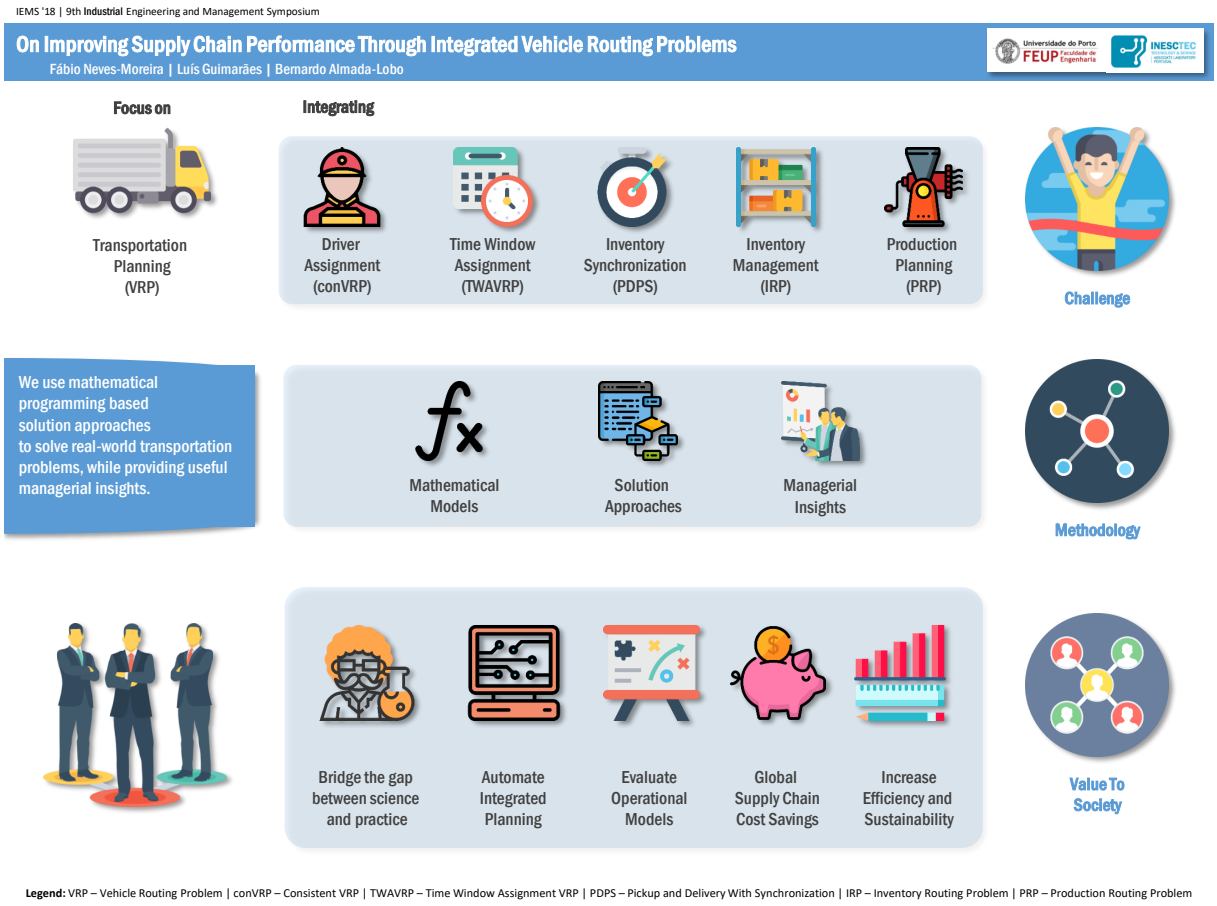

1 The Challenge

The transportation field has been proven to be a truly multidisciplinary one. Transportation related topics are addressed by several university programs and scientific journals in a diverseness of areas such as operations research, economics, engineering, computer science, among others. More than 50 years have passed since the Vehicle Routing Problem (VRP) was introduced and, quite significantly, transportation planning has been a central area of investigation in operations research. Given the highly competitive environment in which companies operate nowadays, it has become crucial to optimize their distribution supply chain processes. To seek for further efficiency improvements, companies are more and more open to test new operational models using sophisticated models and algorithms. A new trend in operations research, helping companies to achieve new levels of excellence, deals with integrating the VRP with inter-related supply chain processes. The technological advances in computing power enable both researchers and practitioners for solving larger optimization problems. However, the stage of maturity regarding Integrated Vehicle Routing Problems (iVRPs) literature is still in its infancy. Our challenge was conceived so as to mitigate some research gaps and contribute to the field of iVRPs at three distinct levels: (1) we

introduce new problems and propose novel mathematical formulations with increasing levels of realism; (2) we develop new decomposition, exact, and approximation algorithms to efficiently explore the structure of several integrated routing problems, validating them within real-world contexts; (3) we provide managerial insights on several classes of iVRPs (Figure 1). We aim at adding value to the transportation field by fulfilling the needs of both the scientific community and practitioners.

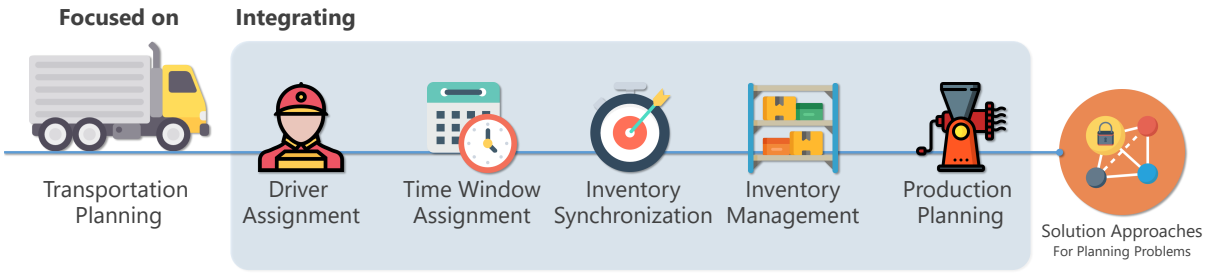

Figure 1: Using operations research techniques to jointly optimize transportation planning with interrelated supply chain processes.

2 The Methodology

To achieve our objectives, we tackled a set of transportation problems, integrating several supply chain decisions. Table 1 overviews the optimization problems that have been studied in our research. In each optimization problem, we integrate different supply chain processes and/or planning horizon levels. Furthermore, we devise an efficient solution approach to optimize the proposed objective function which, in most cases, is composed by more than one type of cost. We provide managerial insights regarding different real-world contexts including third party logistics operators, meat store chains, food retailers, and pharmaceutical distributors.

Table 1: Summary of the integrated vehicle routing problems considered.

Optimization Problem	Supply Chain Process	Planning Horizon Level	Solution Approach	Objective Function	Managerial Insights
PDP	Transportation + Inventory Synchronization	Operational	MH	Maximize Request Movements	Third Party Logistics Operator
IRP	Transportation + Inventory Management	Operational	E	Minimize Inventory And Transportation Cost	Theoretical Study On Transshipments
PRP	Production + Inventory Management + Transportation	Operational	MH	Minimize Production Inventory And Transportation Cost	Meat Store Chain
TWAVRP	Time Window Assignment + Transportation	Tactical + Operational	MH	Minimize Fleet And Transportation Cost	Food Retail Operations
conVRP	Time Window And Driver Assignment + Transportation	Tactical + Operational	MH	Minimize Penalty And Transportation Cost	Pharmaceutical Industry

Legend: MH - Matherustic | E - Exact Approach | PDP - Pickup and Delivery Problem | IRP - Inventory Routing Problem PRP - Production Routing Problem | TWAVRP - Time Window Assignment Vehicle Routing Problem conVRP - Consistent Vehicle Routing Problem

We divide our work into two branches which pose different modelling challenges. The first branch deals with the integration of the VRP with other supply chain processes (rows 1-3 of Table 1). The second branch focuses on integrating the VRP with different planning horizon levels (rows 4-5 of Table 1). Five novel mathematical models are proposed to model each of the realistic contexts considered in this work.

Regarding the solution methods developed to solve the proposed models, two main approaches were used. Firstly, an exact method has been devised in the work related to the use of lateral transshipments when routing inventories (row 2 of Table 1). In this approach, violated subtour elimination constraints are dynamically added to the model. Furthermore, to accelerate the branching process, infeasible routing solutions are heuristically turned into feasible and re-injected into the model. Secondly, several hybridized approaches, i.e. matheuristics, have been proposed to solve the remaining models. Indeed, the flexibility provided by matheuristics proved to be extremely handful to deal with large optimization problems considering realistic features. On one hand, tuning the size of subproblems is a simple task when using available general-purpose solvers. On the other hand, devising and testing different business related decomposition strategies to seek for solution improvements is straightforward. To provide managerial insights, we perform several sensitivity analyses, considering a set of performance indicators and planning parameters that are usually considered in real-world situations. Generally, we seek to understand the impact of different planning settings (i.e. planning horizon duration), delivery modes (i.e. allowing empty trips or not), and realistic features (i.e. demand uncertainty) on the total cost of operation.

3 The Value to Society

Undoubtedly, without freight transportation our economic system would be unsustainable and civilizations, as we know, would simply be non-existent. With the development of new business models, new transportation problems are arising and it is crucial to understand their interaction with interrelated supply chain processes. For instance, understanding the impact of transportation times may be critical for certain business contexts. Amazon is now providing a service for moving extremely large amounts of data using trucks because it is faster than sending the data through the speediest internet connections available. The decision to start such business model is based on the interaction between different modes of transportation (i.e. transfer data through the internet or by truck) with other activities. We consider that providing new methodologies to support these decisions is crucial for the sustainability and efficiency of companies operating in a wide variety of businesses. Therefore, the hardness of vehicle routing problems needs to be tackled in conjunction with different supply chain processes and planning horizon levels. Clearly, researchers have an important role in fostering the use of operations research techniques for further improving practitioners' supply chain management decisions.

Supply Chain Risk Rating: A basal assessment framework derived from Complexity and Continuity

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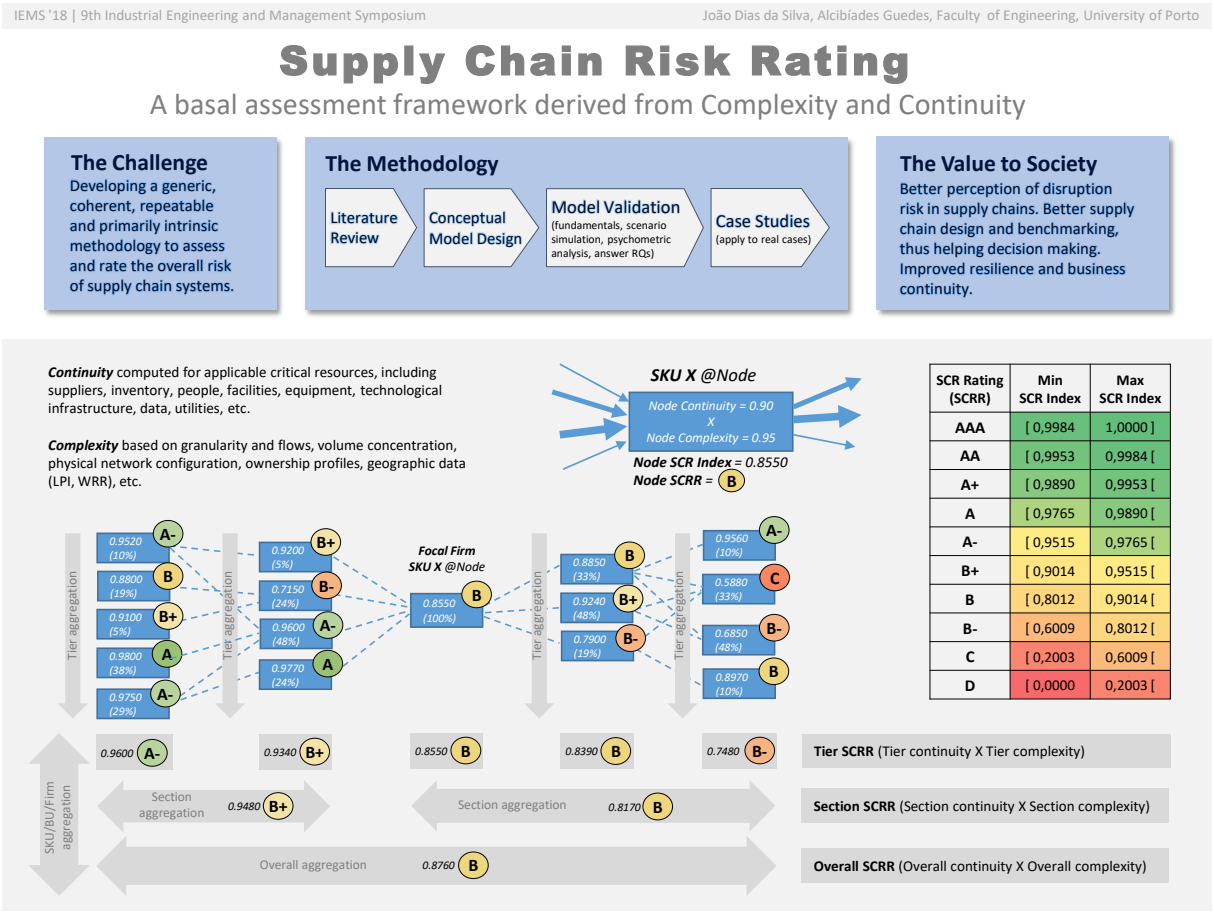


1 The Challenge

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 technology, bring on new sorts of uncertainty, alongside increased volatility, complexity and ambiguity. Within this environment, the design of resilient supply chains has become a challenge of the utmost importance, and so has the need for innovative methods and tools that can assist in measuring and monitoring risk in supply chain systems.

Supply chain risk management (SCRM) frameworks are 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, as well as by a number of specific models developed at company/conglomerate level. Recent research on SCRM has already tackled this challenge, but most "aggregate" approaches tend to address one-off decisions based on supply-side risks alone, or to use risk models that are mainly driven by financial impacts. In addition, current research is typically devoted to specific industry/sector contexts, is sometimes based on subjective (or "hard to get") data/information, and does not formally contemplate the assessment of supply chain subsets. This research project aims to address the need for an innovative, effective and versatile "aggregate" methodology, thus the following research questions have been formulated: (RQ1) *"Which common criteria and modelling procedures should be used to assess the risk of disruption in supply chains, 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 disruption risk 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, effective and versatile (yet, straight-forward and evidence-based) 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, procedures, criteria and output sensitivity (through mass supply chain scenario simulation), and (iv) the application of the model to real cases (for illustration and improvement purposes). The project is currently on phase (iii).

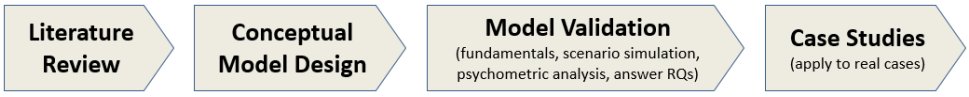


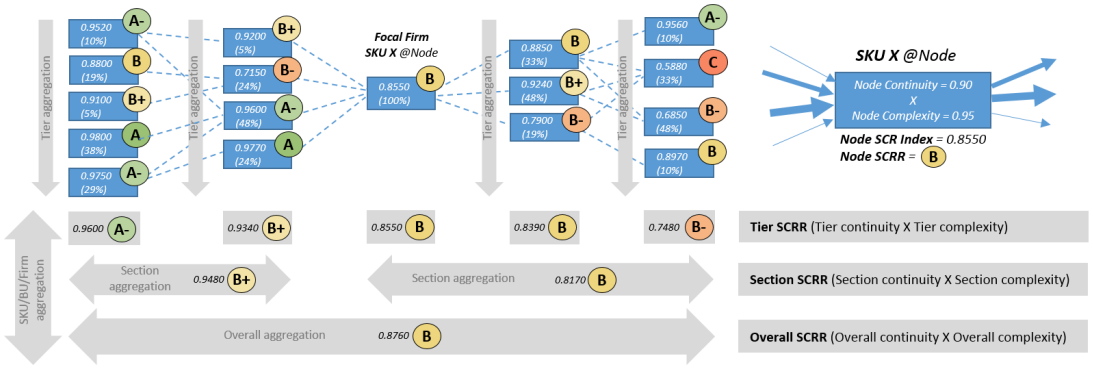
Figure 1: The research methodology

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* it is meant that the proposed rating methodology should be stable and consistent throughout time, allowing current output to be compared with past or future results. Finally, by *primarily intrinsic* it is meant that the proposed methodology should be essentially based on observed features and objective measures obtained from within the system, rather than on perceptions, estimates or any other subjective measures.

On the one hand, there is strong evidence that higher network complexity (e.g. higher operational granularity, larger product ranges, longer networks, larger number of connected nodes, etc.) generally drives up the propensity for supply chain disruption. On the other hand, 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" also sends us a clear signal about the need for continuity planning to cope with unpredicted or unknown conditions. Following this logic, instead of putting most efforts into the identification and analysis of all plausible risk sources for a supply chain system (which is obviously a useful exercise), our main focus is rather on deriving the natural overall propensity for disruption of a

certain supply chain system from both its *Complexity* and its *Continuity* features. *Complexity* depends on measurable network intricacies (as designed), while *Continuity* relies on the actual planning/preparedness to cope with disruption (as managed).

The model is being tested for product and product-service supply chains only. 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 production or storage facility and potentially entails inbound/outbound sub-processes. Processes at a certain location may be split into two or more connected nodes/sub-processes. At each node/process, the preparedness status is determined for a list of applicable critical resources (e.g. suppliers, inventory, people, facilities, equipment, technological infrastructure, data, utilities, etc.) by comparing effective RTO ("Recovery Time Objective") and MTO ("Maximum Tolerable Outage") metrics. A *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. The aggregation procedures also employ *Complexity* factors derived from observed features and contextual conditions at node, section and overall levels, such as: granularity and flows, volume concentration, physical network configuration, process ownership profiles, etc. as well as some generally accepted indexes based on geographic location (e.g. "Logistics Performance Index" by the World Bank, "World Risk Report" indexes by the UNU-EHS). 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" (SCRR) is determined within a 10-level exponential scale where "AAA" corresponds to the highest basal resilience (i.e. lowest propensity for disruption) and "D" corresponds to the lowest basal resilience (i.e. highest propensity for disruption).



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

Figure 2: Determining the SCR Rating (SCRR)

The validation of this construct requires: (i) a large scale simulation of supply chain scenarios, (ii) the computation of the "SCR Index" (and corresponding " SCR Rating") for each of them, and (iii) an integrated analysis of the results, including a number psychometric attributes, namely *acceptability*, *internal consistency*, *validity* and *responsiveness/sensitivity*. The construct will also be applied to some real cases (supply chains of different sizes and industries), which will 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 Standard-

isation Organisation (ISO) established a new Technical Committee ISO/TC 292 on the field of "Security and Resilience", which is in charge of important standards such as the ISO 22301 ("Business Continuity Management Systems"), the ISO 22316 ("Organisational Resilience") or the ISO 28000 series ("Supply Chain Security Systems"). Curiously enough, a new document named "Guideline for complexity assessment process to improve security and resilience" (ISO/DTS 22375) is currently under development. These signals 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. purely 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.

Smart Energy Services and the Service Logic Perspective: Getting Closer to Final Customers

Luísa Goncalves*, Lia Patrício*

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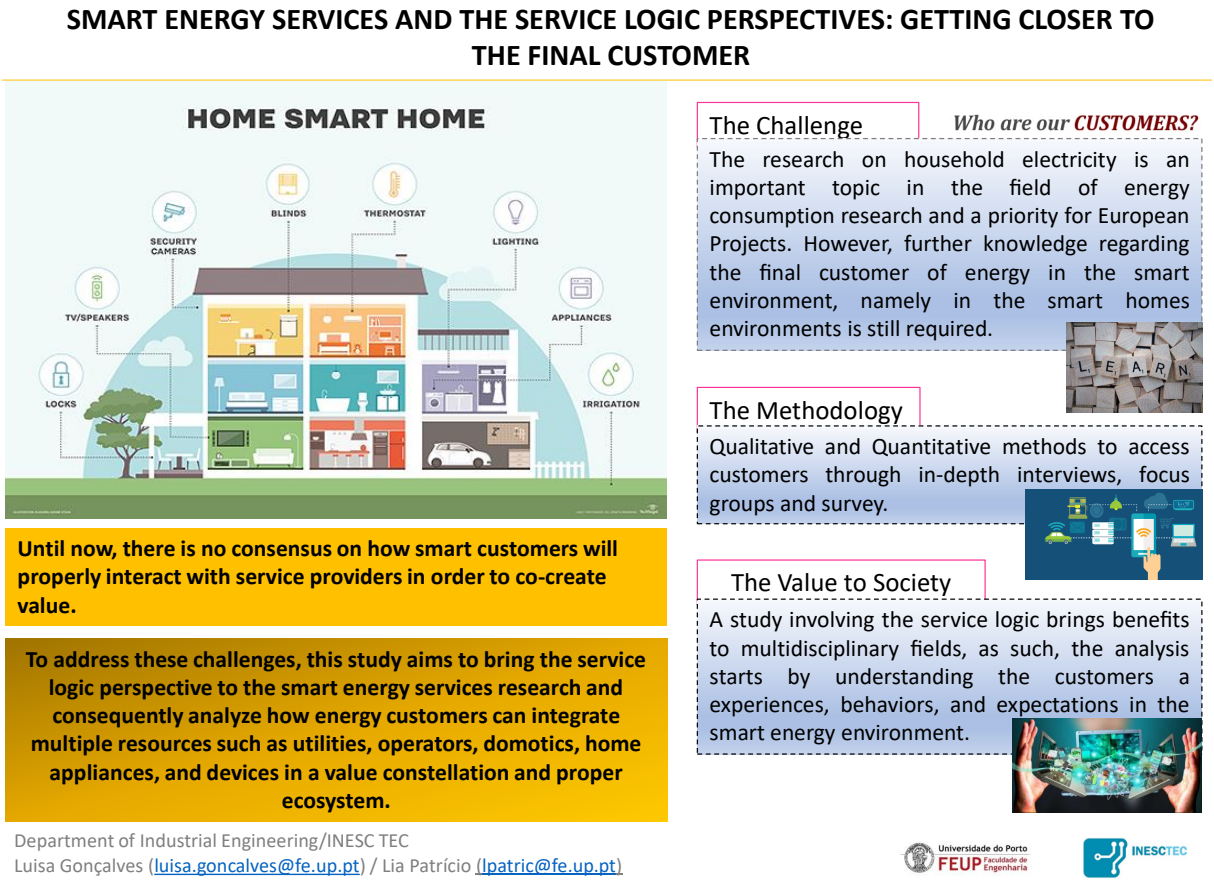

1 The Challenge

In the latest years, energy efficiency and saving have become key problems due to the increase in energy consumption, energy prices, and concerns about the environmental changes. The research on household electricity is an important topic in the field of energy consumption research and a priority for European Projects, utility companies and system operators. However, further knowledge regarding the final customer of energy in the smart environment, namely in the smart homes environments is still required. Until now, there is no consensus on how smart customers will properly interact with service providers in order to co-create value and set partnerships. Energy literature indicates a growing interest in how smart services in smart grids might be part of a more sustainable future. There is no fixed definition of a smart service, but an understanding that smart services are those that are delivered to or, via digital sensing and communication devices that are able to sense its own condition and its surroundings, and thus, allows data collection in real-time, continuous communication and interactive feedback. Crucially,

these devices communicate with each other seamlessly, in order to provide a more sophisticated control of energy, greater security against break-ins and innovations in home ambiance. These services are grounded in the smart grid technology that integrates information and communication technologies (ICT) into the existing network to enable a two-way flow of information and electricity between producers and consumers. This possibility changes completely the relationships in the service network because it enables the customer empowerment and participation in more active home energy management and consumption, with significant impacts on effectiveness, efficiency, and sustainability of energy use. Thus, there are many great expectations to how these networked technologies will transform homes and everyday life, but they often seem far from reality in the energy sector because customers have been largely resistant to making their energy systems smart, representing a huge challenge to private and government entities. This issue is, for instance, prioritized in the European Union H2020 funding schemes, including the SET (Strategic Energy Technology) plan and its integrated roadmap. This sets out the goal of secure, affordable and sustainable energy and states that this goal can only be reached with the embracement of the new smart energy technologies. In this sense, the active participation of citizens is considered crucial to this strategy and it is made clear that citizen participation and engagement are key parts of smart home services and solutions, although the documents tend to be vague about the form that this engagement should take. Meaning that mechanisms or service offerings are missing, and the knowledge of the main concepts and goals of these offerings is still fuzzy. To address these challenges, this study aims to bring the service logic perspective to the smart energy services research and consequently analyze how energy customers can integrate multiple resources such as utilities, operators, domotics, home appliances, and devices in a value constellation and proper ecosystem. Consequently, identifying the implications of moving from smart grids to smart energy services by engaging customers and potentially enabling them to co-create value with smart energy services.

2 The Methodology

The research method integrates the constructive and holistic perspective of Service Research to analyze the various aspects involving the final customer of energy, namely the customer engagement, context factors, value constellations and multiple interactions. The study integrates literature on smart services, service research, smart grids, and customer engagement to propose a new perspective on smart energy services by considering the final customer as the central element of the smart service ecosystem. In order to capture and characterize these customers, qualitative methods, namely interviews and focus groups are being performed with early adopters of a specific smart energy service offered by a Portuguese utility company. These customers are also owners of electric vehicles and use clean energy sources to generate their own energy, such as photovoltaic panels. In-depth interviews and focus groups will allow gathering reach insights regarding ecosystem actors role, connections, activities, interactions, value exchange, consumption behavior and attitudes, and goals for the future. The intermediate step refers to the quantitative part that aims to measure the impact of interactions with multiple resources, namely utilities, operators, domotics, home appliances, and devices in a value constellation and proper ecosystem. In this context, a survey will be developed based on the results obtained in the first stage. Data collection of the qualitative is ongoing and the combination of different methods (mixed-methods) during the research steps will provide an increased validation of data collection. Consequently, the analysis of energy final customers will reveal complementarities that can bring important insights to developing integrated service offerings that engage the customer by enabling them to co-create value in new ways, highlighting that many opportunities may arise from looking smart grids technology from a service perspective.

3 The value to Society

Despite progress in smart grids implementation, potentialities and problems related to the customer immersed in the smart context of energy remain largely unexplored. In the last five years, interest has been growing due to the imposition of gaining knowledge about the final customer of energy, to understand the reasons they tend to reject this new technology, which brings benefits for the planet ecosystems and for society in general. In this context, a study involving the service logic brings benefits to multidisciplinary

fields, as such, the analysis starts by understanding the customer experiences, behaviors, and expectations in the smart energy environment. In order to develop new services based on these inputs, it will be necessary to understand also the actors and activities in the service network, namely stakeholders, value constellations, multiple interactions nature, business models, internal processes, and internal and external contexts of operators and utilities. Consequently, the study is naturally extended to the analysis of each of these main topics, generating a rich body of knowledge that will support the smart energy service offerings in the future.

4 Acknowledgements

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Service Design multidisciplinary perspectives: identifying shared concerns

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1 The Challenge

Service Design is a multidisciplinary, human-centered, collaborative, holistic approach focused on creating new service or improving existing one. Although researchers have characterized multidisciplinary perspectives on Service Design and their related contributions, such as from Design, Interaction Design, Service Marketing, Operations, Information Systems and Service Research, there is still a lack of a comprehensive understanding of Service Design as an integrated multidisciplinary approach. Different academic communities have been approaching Service Design, resulting in different concepts, approaches and languages. This lack of integration hinders the dialogue and shared ground between Service Designers coming from different backgrounds, risking to researchers and practitioners building knowledge in silos, reinventing the wheel and eventually hampering the potential of Service Design to foster service innovation.

2 The Methodology

To identify and examine complementarities between different perspectives on Service Design, a qualitative study was conducted comprising focus groups with six Service Design research centers, from 5 different countries, involving researchers from multidisciplinary backgrounds. These centers were chosen, because of their leading role in representing the aforementioned areas that contribute to Service Design. The main research perspective of each Service Design Center (SDC) is reported as follows: SDC-1, Information Systems; SDC-2, Operations Management; SDC-3, Interaction Design and Design; SDC-4, Design; SDC-5, Marketing and, SDC-6, Service Research. The transcriptions of the focus groups were examined in the Nvivo software, following qualitative research principles.

3 The value to Society

This study identified shared concerns among multidisciplinary perspectives on Service Design, using service system as an integrative abstraction. A service system perspective is used as an integrative concept to coordinate Service Design multidisciplinary competences along different levels, highlighting shared concerns in terms of actor-centered approach, processes and interfaces and the design of new constellations of actors and their connected roles. At an individual-actor level, the shared concern of an actor-centered perspective is identified, which is composed by human and provider-centered approaches. A human-centered approach is integrated by user, customer and employee foci, which bring complementary knowledge from multidisciplinary perspectives to design for new service. At an organizational service delivery system level, a shared focus on processes and interfaces is described. In the first case, results show that multidisciplinary perspectives on Service Design bring specialized competences to integrate different resources along the service design process. In the second, results demonstrate different concerns and approaches to service interface (e.g. service clues, servicescape, user interface), that when integrated can support professionals to coordinate different types of resources that compose service interfaces within service systems. Finally, at a network and ecosystem levels, results show a common interest in designing for new constellations of actors and their connected roles. In this context, coordinating multidisciplinary competences proves to be an important goal to communities and society in general, as by creating service platforms, enabling more sustainable solutions and fostering institutional change. All in all, this study contributes to enhance communication and collaboration between Service Designers coming from different backgrounds, by elucidating the use of common concepts and indicating complementary contributions from multidisciplinary knowledge along different levels of service systems.

4 Acknowledgments

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Solving the backroom design problem in grocery stores

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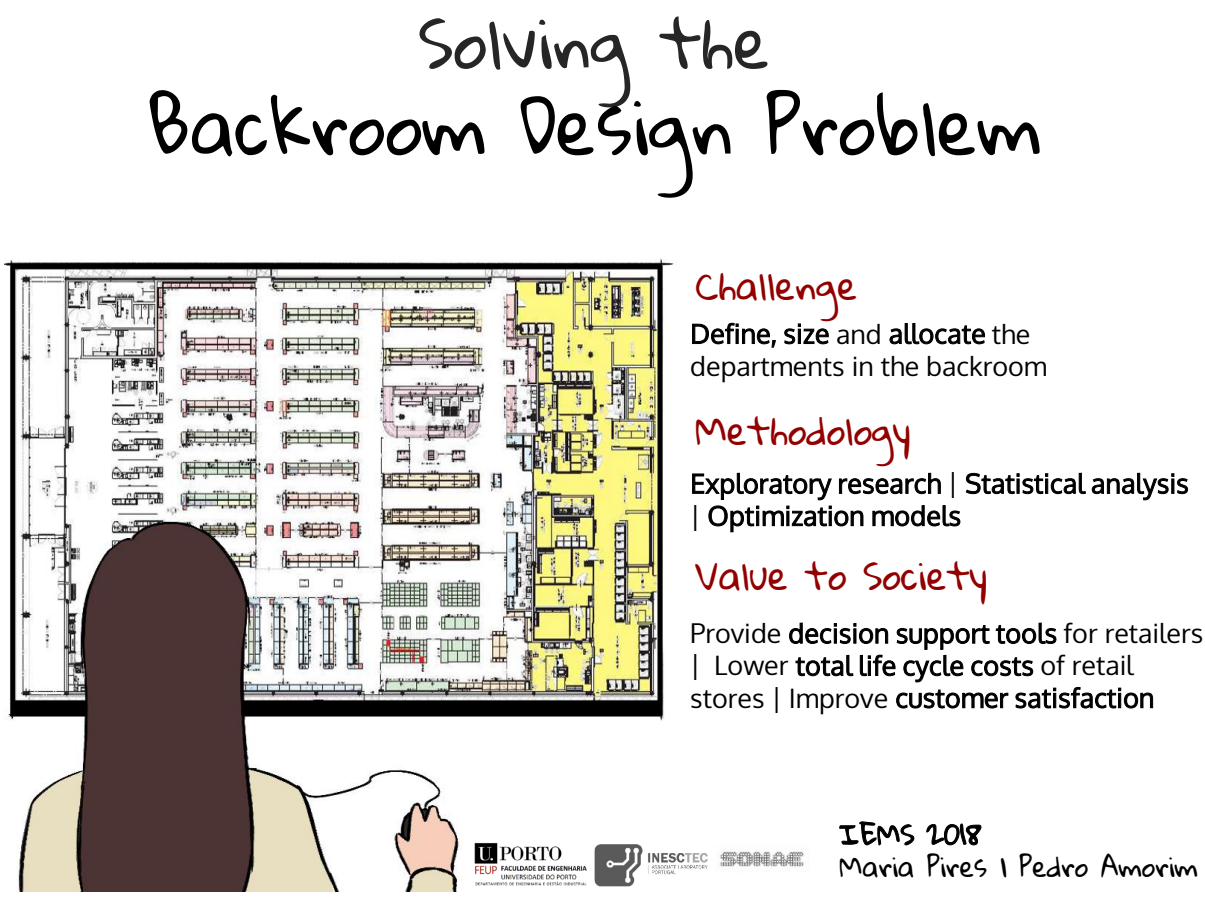

1 The Challenge

The ongoing transformation of retail is impacting every aspect of its operations, requiring ever greater operational efficiency, namely regarding the optimization of the store scarce resources, such as the store space.

Conventional stores are usually divided in two areas: sales area and backroom. Backroom storage is essential in retail stores since the replenishment orders for a given item that arrive at a retail store, coming directly from suppliers or distribution centres, may not fit on the allocated shelf space. Moreover, nowadays, backroom storage in retail food stores is becoming more vital to act as a buffer against strong demand lifts yielded by an ever increasing promotional activity, seasonal peak demand for particular categories of products and on weekends, as well as to accommodate other activities, such as e-commerce.

In the store designing process, sales area design is the priority since it corresponds to the space that creates direct value to the store. In contrast, the remaining space is dedicated to the backroom storage,

which has the design process often neglected. Currently, in practice, the design of the backroom areas is mainly established on the perception of the architect, which is based on similar stores, when instead it should be carefully studied, considering in-store logistics, expected orders' volume of regular, seasonal and promotional activity. Additionally, the literature on this topic is very scarce.

In this presentation we will address the methodology developed to solve the backroom design problem. To design the backroom areas, firstly, one needs to know how many departments are required, their size (in m^2) and, lastly, their location in the backroom. Since this is an extremely complex problem, it was divided into smaller sub-problems. The first sub-problem aims to forecast the backroom storage requirements (i.e., number of storage units to be kept in the backroom). Then, the second sub-problem translates the storage requirements into floor space (m^2), by minimizing the backroom life cycle costs. Lastly, the backroom layout problem allocates the departments in the backroom in order to minimize the walking distances in the store.

The backroom design problem is a strategic problem with several design particularities, being the most relevant probably its dependence on the type of store and the sales area configuration. For this reason, there is no one-size-fits-all solution for backrooms. However, merchandising and store operations have little time to devote to backroom efficiency and design, much less the knowledge on how to perform it. With this research, we aim to fill the gap in the retail operations literature, by providing further insights regarding backroom areas and how to design them. Furthermore, we also make a contribution to practice, since we have developed groundwork for a decision support system to automatically design the backroom areas. Despite the straight link with the case study, the mathematical models that emerged from this thesis are extensible to other food or non-food retailers.

2 The Methodology

In order to tackle this complex problem firstly, a thorough literature review on backrooms, grocery retail, in-store operations, warehouse design and operations was conducted. 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 research 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 also able to map the productsâ flow within the stores which will be the cornerstone for layout definition and department organization within the backroom area.

The literature review and exploratory research previously performed allowed us to define a conceptual model for designing the backroom areas. This framework consists in seven sequential steps of decisions and have the purpose to guide retailers in defining their backroom areas in a standardized and efficient manner. The proposed framework combines the frameworks in the literature for designing conventional warehouses into one single structured approach that is adapted to the reality of retail stores and that incorporates the inefficiencies captured in the exploratory store visits.

Next in our research, we developed qualitative models to design the backroom areas. During this research we have worked together with an European grocery retailer, which allowed us to use real data, as well as to validate our achievements. As previously referred, we divided the backroom design problem into smaller sub-problems, described bellow.

1. **Forecasting model** The goal of the forecasting model is to determine the storage requirements (stock) for a new store. When a store is being designed, the expected demand (store sales) and inventory are not known. The goal of the forecasting model is to determine this important information to support store design. In order to do so, we started by grouping stores that share similar sales patterns into clusters, using the k-means technique. Then, we developed multinominal logistic regression models based on data of existing stores. The independent variables are the store clusters, previously defined, and the dependent variables are the store characteristics such as, store type, location and type of client. These models allow to allocate a new store to a cluster. Once store expected sales are predicted, it is possible to determine the storage requirements in the backrooom.The forecasting model was validated using data from thirty stores and resulted in deviations

of 3% in stock quantities.

2. **Sizing model** Two parallel approaches were developed to size each storage department. Both the approaches are mathematical models. The first is a bottom-up approach that aims to determine the size of each department by minimizing the backroom life cycle costs (storage, construction, maintenance and material handling costs). The top-down approach consists in a DEA-inspired model that performs a benchmark analysis of existing stores. In other words, it finds the most efficient backroom which is the one that uses less storage space for similar storage requirements. These models allow to reduce backroom space in 38% and 19%, respectively.

3. **Backroom layout model** This optimization model determines the location of each departments by minimizing the walking distances of employees in the store. The model considers architectural constraints, sales area layout, different department replenishment frequencies and energy issues. The results of this model were compared with eight store layouts. By using the proposed model, the walking distances in the store were reduced by 30%. This has a great impact on in-store logistics, mainly in the shelf stacking process, which allow to reduce out-of-stocks and, ultimately, improve customer service level and store sales.

3 The Value to Society

The fist contribution concerns the advance of the scientific knowledge in a topic that is rarely addressed in the literature, both qualitative and quantitatively. On one hand, we describe the in-store operations, frequent layout problems pointed out by store managers and the current process of designing backroom layouts. On the other hand, we develop innovative models by taking advantage of models applied in other contexts.

From a practical point of view, we expect to achieve cost savings in the construction, storage and material handling of backrooms. Furthermore, more efficiently designed storage areas will allow better customer service at the store, which ultimately will translate into an increase in sales. Moreover, it is also our purpose to guide retailers in defining their backroom areas in a standardized and efficient manner. We have been working closely together with the Portuguese leading food retail chain to tackle the backroom design problem and to develop a Decision Support System to assist the designers in the store construction or remodelling processes. Therefore, this academic research is being applied to real problems and bringing actual benefits to the grocery retail industry.

A robust optimization approach for the vehicle routing problem with selective backhauls

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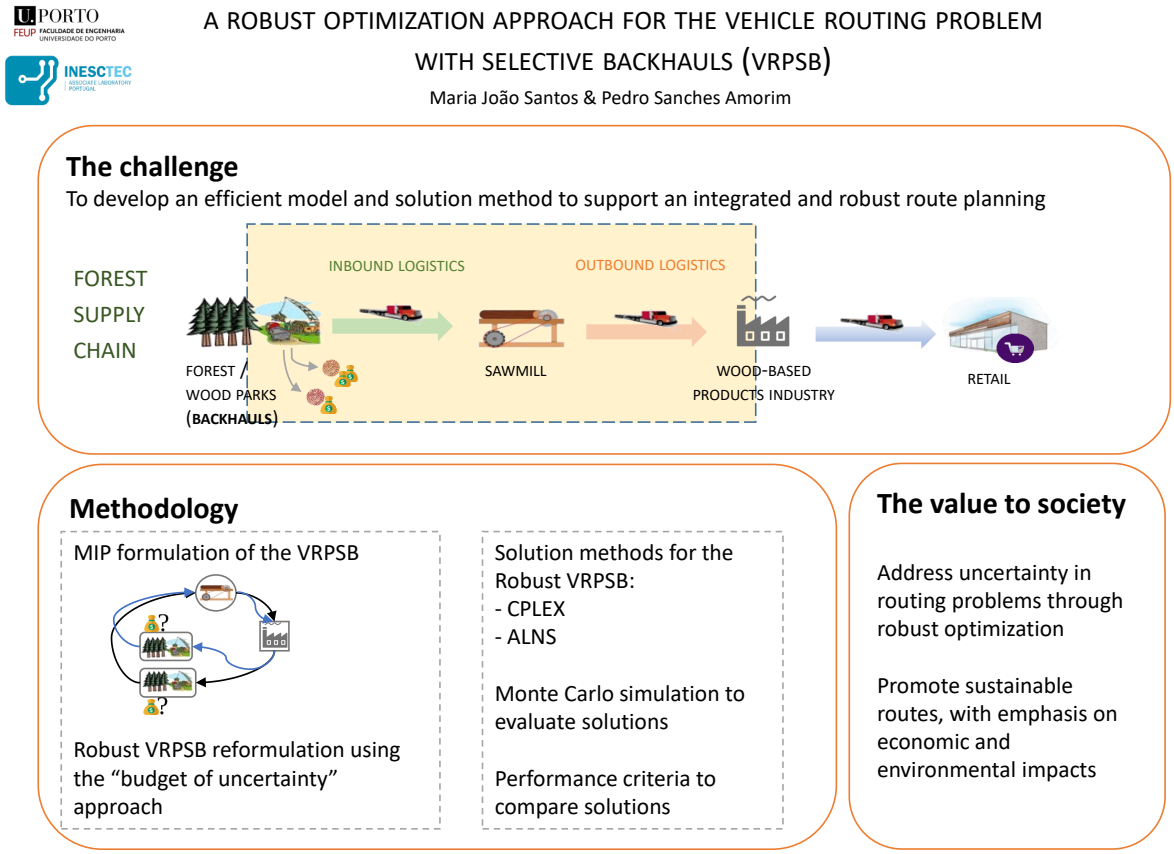

1 The Challenge

Today, green logistics plays a major role in improving the sustainability indicators in all supply chains, as transportation alone comprises 30% to 60% of total logistics costs and about 18% of the total greenhouse gases (GHG) emissions. One possible green strategy to improve the sustainability in transportation is to plan the routes using an integrated inbound-outbound logistics perspective. In this case, in each route, a match is tried between delivering of all customers requests (outbound route) and the pick up of raw material from suppliers in the way back (inbound route). In the operations research community, this problem is known as the Vehicle Routing Problems with Backhauls (VRPB), where the customers are classified as linehauls, if visited during the outbound route, and backhauls, if visited during the inbound route. Such green strategy can substantially decrease the total distance traveled and the fuel consumed, and, in consequence, reduce the total costs and negative effects on the environment.

In the forest supply chain, the VRPB has a huge potential to decrease the transportation costs by integrating routes from wood parks to a sawmill (inbound) and from the sawmill to a diversified set of industries that manufacture wood-based products (outbound). Considering that forests have large amounts of wood, usually, a single wood park can provide sufficient raw material to the sawmill. Therefore, one of the decisions in planning integrated routes is choosing which backhaul should be visited. Certainly, the decision will favor the backhaul that contributes the most to minimize the total routing costs (cost related to the distance travelled minus revenue related to the wood brought into the sawmill). When optional visits to backhauls are considered in the problem, this becomes the Vehicle Routing Problem with Selective Backhauls (VRPSB). Other application of the VRPSB can be found in reverse logistics, since the revenue obtained from visiting a backhaul customer, that provides the material to recycle, is related to the quality or characteristics of that material.

The revenue provided by forests is usually related with particular properties and quality of the wood such as, density or moisture content. Given that the wood in forests is subject to weather conditions that may change its properties, and that, usually, there are no direct methods to measure these properties with regular frequency, there is uncertainty regarding the wood quality when this is picked up by a vehicle. Although much literature can be found regarding the optimization of VRPs under uncertainty, no study was yet carried for a VRPB or a VRPSB under uncertainty. Moreover, very few works in that literature report uncertainty in revenues. Uncertainty in revenues have a direct impact on the total routing costs, since the real profit becomes the difference between the revenue of a backhaul and the distance traveled to visit it. Unlike uncertainty in demand, that influences directly the constraint on the loading capacity of vehicles, the uncertainty in revenues is more related to the objective function.

The most well-studied approach to tackle uncertainty in VRPs is stochastic programming that uses the knowledge of the probability distribution of the uncertain parameters as the most valuable input for the planning. However, it is common that no detailed information about the probability distribution is available. In this case, robust optimization is a suitable approach to use, where, instead of assuming a probability distribution, the uncertainty is represented as a bounded set and the goal is to guarantee the feasibility for all potential realizations of the uncertainty. Robust optimization is the most recent trend in optimization problems under uncertainty, but there are still some gaps to be filled and multiple possibilities of improving the pioneer models in this research stream.

The main challenges of this work are: i) to develop a model and solution method to deal with uncertain revenues using a robust optimization approach; ii) to provide the study of a problem not yet covered in literature (Robust Vehicle Routing Problem with Selective Backhauls) but with high application in real-world activities, such as in the forest supply chain; and iii) to gather insights on the properties and robustness measures of the related robust plans.

2 The Methodology

The specific objectives of this work are: i) to analyze the impact of the robust parameters of the robust approach for the VRPSB under revenues uncertainty; ii) to compare nominal and robust solutions regarding robustness measures; and iii) to evaluate the computational performance and solution quality of different solution methods.

To address the first two objectives, the deterministic VRPSB is formulated as a commodity flow mixed integer programming (MIP) model and the uncertainty on revenues is included in the objective function of the problem as a robust counterpart. To derive the robust counterpart of the deterministic problem, the uncertainty is represented as a polyhedral set and a parameter Γ, called "budget of uncertainty" is introduced. This parameter allows to control the number of uncertain parameters that may deviate from their nominal values. The budget of uncertainty can be regarded as an analogy to the level of conservatism of the decision-maker. The parameters in the robust model, such as Γ, nominal values and respective deviations, are evaluated using Monte Carlo simulation. Robust and nominal solutions for the VRPSB are evaluated with respect to solution quality and solution robustness, and compared according to specific performance criteria, namely the price of robustness (PoR) and the actual price of robustness (APoR). Solution quality can be assessed through the average, best and worst solutions from the simulation, as well as the standard deviation. Solution robustness is assessed by measuring the

difference between robust and nominal solutions (PoR) and the expected price to pay for using a robust plan (APoR).

To address the third objective, two solution methods are used to solve the robust VRPSB: CPLEX to solve small instances and an Adaptive Large Neighborhood Search (ALNS) metaheuristic to solve larger instances. These instances are adapted from well-known instances in VRPB literature.

3 The value to Society

This paper addresses an under-researched problem - the Robust VRPSB with profit uncertainty. Firstly, this problem is often present in real logistics activities, but research exploring the VRPSB is still scarce in literature. Secondly, only deterministic models were developed so far for the VRPSB (and for the VRPB).

Since robust optimization is an emergent topic in the VRP research community, much effort has been diverted to develop efficient robust mathematical formulations and different forms to represent uncertainty. Perhaps this is the reason why very few metaheuristics were developed so far for the robust VRP. In this work, a robust metaheuristic is designed and evaluated according to its computational performance and solution quality.

Moreover, this paper contributes to identify the properties of the robust parameters in the model to solve the Robust VRPSB and the properties of robust solutions against nominal solutions.

At last, this paper highlights the impact of integrating inbound-outbound logistics in the promotion of sustainability, namely by reducing the number of required vehicles, the travel distance and the GHG emissions.

Understanding commercial synergies between public transport and services located around public transport stations

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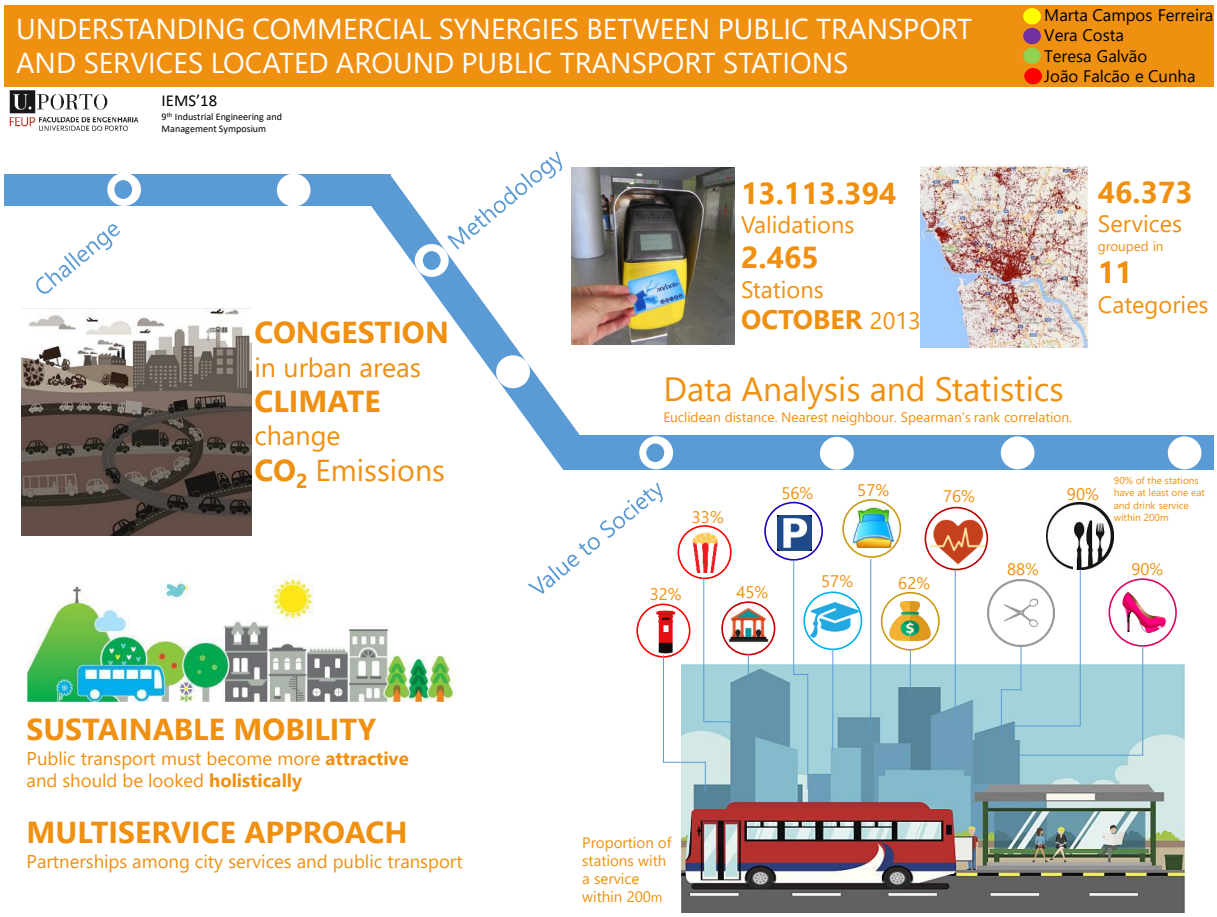

1 The Challenge

Promoting a sustainable mobility is a major concern of many countries around the world. Therefore, the use of cleaner and more efficient transport modes, such as public transport, must be encouraged. The public transport system integrates a complex ecosystem, composed not only by transport operators and travellers but also by other services such as schools, firms, restaurants, museums, banks, and public establishments. Therefore, by adopting a holistic point of view, we propose a new service approach linking city services and public transport. This multiservice approach consists in partnerships that may include discounts, combined packages, reduced prices, deals and marketing campaigns, targeted to each specific audience. In order to develop these partnerships it is important to analyse the services located around the stations and the public transport usage. We use the city of Porto, Portugal, as an illustrative example.

2 The Methodology

To perform the analysis we relied on two sources of data: Automated Fare Collection (AFC) system data and business data points. The electronic ticketing system used in Metropolitan Area of Porto (MAP) is an entry-only AFC system with a distance-based fare structure. The fare media are contactless travel cards, called Andante, which can be used on buses from several operators, as well as on metro and railways. The Andante system creates a transaction record every time a passenger taps a travel card on a reader. This must happen at the beginning of each journey stage, when changing routes or entering another vehicle. Each Andante transaction record contains several data attributes, of which the following are of interest to the proposed analysis: travel card serial number, station or bus stop where the transaction took place, name of the operator, type of card, traveller profile and the zone where the validation occurred with the corresponding coordinates. The data used to illustrate the multiservice approach is the set of transaction records in the whole month of October 2013. October 2013 was a normal month with 23 working days and 8 weekend days. In this month, 13.113.394 validations were recorded. From those, 9.943 validations were discarded since they corresponded to validations with illogical values (stops with the value 0). The remaining validations were performed in 2.465 distinct stops and 76 lines. Finally, the validations corresponded to 714.836 different travel cards.

The second database used for the analysis is based on Google Places API. This is an up-to-date database with information about millions of points of interest (POI) categorized and geographically located. To scan the vast area of MAP, we manually estimated an area of approximately 400 km2, covering the city zones with higher concentration of POIs (see green line in figure 1). After scanning and filtering duplicated results, we obtained 46.373 POIs. The POIs are classified according to 101 categories. We then grouped these in 11 main categories. From the attributes of each place the following are of interest to the proposed analysis: name, category and location coordinates. The POIs were classified according to the following main categories (number of establishments): Accommodation (970), Eat and Drink (4407), Education (764), Financial Services (900), Health (1892), Leisure (334), Public Services (365), Service Businesses (4063), Shopping (5375), Transport (672), Visiting (491).

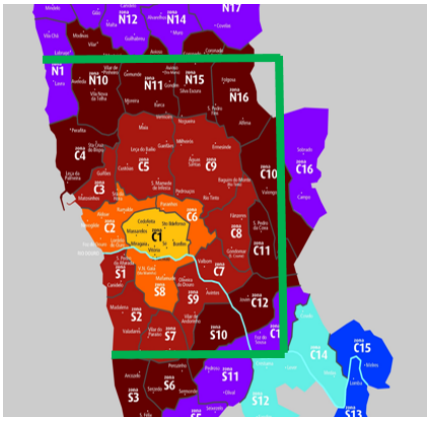

Figure 1: Part of the structure of MAP travel zones and scanned area using Google Places API

In order to make a careful and meaningful analysis of the services located around the stations and the public transport usage, we decided to restrict the analysis to 4 of the 46 geographic zones: C1, C2, C6, and S8. The first three are located in the city of Porto and S8 is located on the other side of the Douro River, in Vila Nova de Gaia. These four zones represent approximately 78% of the validations performed in MAP. In this research, we demonstrate the relationship between bus and metro stations (S) and the existence of city services. The proximity of these two categories was calculated using Euclidean distance, given by:

$$d(p,q) = d(q,p) = \sqrt{\sum_{i=1}^{n}(p_i - q_i)^2} \tag{1}$$

Where p are the coordinates of each service and q are the coordinates of each station (S). Thus, a

nearest neighbour analysis based on F-function was performed (Bailey and Gatrell 1995). F-function is calculated, for a distance d, as:

$$F(d) = \frac{1}{n}\sum_{i=1}^{n} 1(di^t \leq d) \tag{2}$$

Where n is the number of points and di^t is the distance from point i to its first-order nearest neighboring event of type t. I is an indicator function that takes the value of 1 if the argument is true and zero otherwise. The function sums the number of stations or travellers whose first neighboring event (POI) is within a pre-defined distance d of the point, and then divides by the total number of points in the analysis.

In order to compare the number of city services (C) and the number of validations (V), a distance of 300m was fixed and the values of correlation were analysed. To decide the most appropriate method to apply in our data, we tested the normality of the two variables using the Kolmogorov Smirnov test. As both variables have non normal distribution, a Spearman's correlation should be used. Spearman's rank correlation coefficient is a nonparametric rank statistic proposed as a measure of the strength of the association between two variables (Hauke and Kossowski 2011). The Spearman's correlation is given by:

$$\rho = 1 - \frac{6\sum_{i=1}^{n} di^2}{n^3 - n} \tag{3}$$

Where d_i is the difference between the two ranks of each observation and n is the number of observations. The null hypothesis for this correlation is: H_0: There is no association between C AND V. In this work, to perform the analysis, we used the R software and Microsoft Excel.

3 The value to Society

An overall analysis of the location of services around the stations allowed us to identify categories of services with higher and lower degrees of concentration around public transport stations. Therefore, restaurants, shops, and business services, pharmacies and health centres are the services that tend to agglomerate near the stations (see figure 2). Visiting, leisure and public services show decreasing levels of concentration around the stations. Moreover, the areas of the city with higher levels of traffic are also those with higher level of concentration of services. This information is useful for transport operators to identify potential partners and for city services to understand the passengers travel patterns and target service offerings. Local authorities also benefit from such analysis since it is possible to understand the geographic distribution of public transport stations and city services.

The development of partnerships among city services and public transport service providers will contribute to modernize the image of transport operators, improve quality of service, attract new customers and retain the existing ones. On the other hand, it will also boost local businesses, due to increased awareness, loyalty and sales. Customers benefit from convenience, availability, better services, and increased savings.

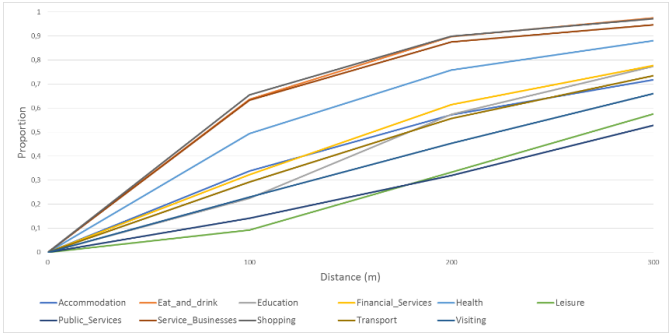

Figure 2: Proportion of stations with a POI within distance d (by service type)

How do the external and internal factors promote or hinder servitization of a manufacturing firm over time? Case-research in the elevator industry

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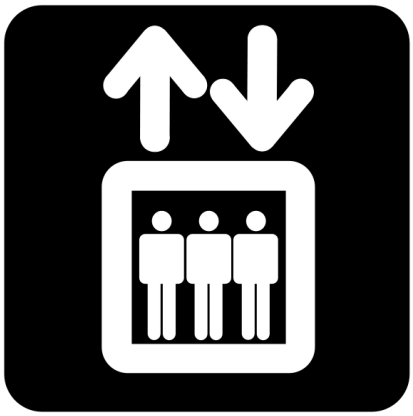
How do the external and internal factors promote or hinder servitization of a manufacturing firm over time? Case-research in the elevator industry.

The Challenge
Which factors may promote or hinder servitization in manufacturing firms? How do they play out over time?



The Methodology
Single retrospective in-depth case study:
Analysis of one multinational elevator manufacturing firm with operations in Portugal.

The Value to Society
This research extends the literature by providing insights into how relevant external and internal factors may promote or hinder servitization of the manufacturing firm over time. Some preliminary results are:

- Adoption of facilities that are located in close physically proximity to the customer over time enables responsive and reliable maintenance, increasing also the provision of other services, like overhaul or modernization.
- Creation of a separate organization to handle the service offering by developing a dedicated sales force and a structure with dedicated service managers and technicians positively impacts the servitization over time.
- By including more services in its total offering, the manufacturer tends to balance the effects of economic cycles with different cash-flows, since services tend to reduce the vulnerability and the volatility of cash-flows over time.

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1 The Challenge

The boundaries between manufacturing 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 service-led competitive strategy and the process through which it is achieved is commonly referred to as servitization. Integrated product-service offerings can be distinctive, long-lived, and easier to defend from competition of lower-cost economies, being a conscious and explicit strategy for market differentiation. Much research has been dedicated to the design and benefits of integrated product service offerings from a manufacturer perspective. For instance, servitization could lead to higher revenues and profits. Servitization seems to be driven from both the outside (the organisational environment circumstances impacting the manufacturing firm, or external factors) and within the company

(through direct managerial decision-making, the internal factors). Notwithstanding, only a limited number of studies have examined how these external and internal factors promote or hinder servitization over time. 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. In order to address these gaps, the objective of this study is to provide insights into which factors may promote or hinder servitization in manufacturing firms and how they play out over time. Specifically, we conduct an in-depth case study of a manufacturer in the elevator industry in Portugal. The elevator industry was chosen because transition to services is still an open issue in this industry, while covering a broad spectrum of service offerings, from base to advanced services. Elevators are long-lived, technically complex equipment that demand high safety requirements and therefore ongoing maintenance and inspection. Finally, a single case study may lead to in depth insights that are unobtainable in quantitative studies.

2 The Methodology

The empirical context for the study is the elevator industry in Portugal. The research is based on the analysis of one multinational elevator manufacturing firm with operations in Portugal, through a retrospective case study. A case study is a history of past or current phenomena, drawn from multiple sources of evidence. It can include data from direct observation and systematic interviewing, as well as from public and private archives. Case research is considered one of the most powerful research methods in operations management, and has been recognised as being good for examining the how and why questions. It is also suitable for developing new theory and ideas and can also be used for theory testing and refinement/ extension. By investigating a contemporary phenomenon within its real-life context, the case study can also be used to examine more deeply and validate previous empirical results. A conceptual framework that underlies the research is presented in figure 1. This framework explains the main aspects to be studied (the key factors, constructs or variables) and the presumed relationships between them. The framework developed was used as a lens for analysis by synthesizing the framework into a semi-structured interview protocol. In order to enhance the reliability and validity of the case research data, a research protocol was developed. This protocol contains the procedures and general rules that should be followed in using the instrument, and indicates from whom or from where different sets of information are to be sought. The core of the protocol is the set of questions to be used in interviews. It outlines the subjects to be covered during an interview, states the questions to be asked and indicates the specific data required. This ensures that all areas of enquiry were covered.Our data consists of a wide range of material: semi-structured interviews with senior managers, memos of workshops with the key decision makers, the internal documents and presentations, data on delivered goods and services, a brochure about the historical development of the company, and participant observation by the author on the premises of the company during the research period. The interviews lasted 60-120 minutes and were conducted over a period of two months. Throughout the study, following each interview a thematically arranged outline describing the covered issues was written. There were a total of 12 interviews carried out (1 CEO, 2 senior service managers, 2 senior new installation managers and 7 service managers). All of them were recorded. Additional interviews were carried out until theoretical saturation was reached, that is, when no new information emerged. Additional methods of data collection were used to triangulate the data obtained from the interviews, including a review of company documentation, publicly available information and site visits. Case study reports were prepared and sent to the interviewees to validate the data and maintain participant engagement in the research process. Once data were collected they were documented and coded, in order to reduce data into categories. Thereafter a pattern analysis of the data was conducted in order to look for causality.

3 The value to Society

Much research has been dedicated to the design and benefits of integrated product and service offerings. But only a limited number of empirical studies have considered how the relevant factors promote or hinder servitization. This research extends the literature by providing insights into how the relevant external

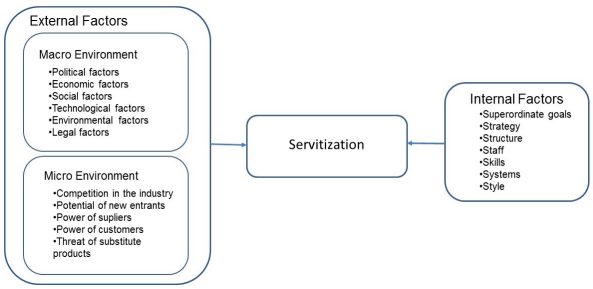

Figure 1: Conceptual Framework

and internal factors may promote or hinder servitization of the manufacturing firm over time and under which circumstances. This study is still ongoing and we will present only some preliminary results.

The studied company adopted, over time, facilities that are located in close physically proximity to the customer base in order to extend their offerings by providing product-centric services. There is a positive impact on product performance and availability, because the manufacturer can respond more quickly. Service staff tend to be available more quickly when a failure occurs and providing corrective actions more quickly and precisely assuring a faster fault diagnostics and faster response to a problem. Thus, this capability enables responsive and reliable maintenance, increasing the provision of services. Localized facilities also create and sustain a strong relationship between the manufacturer and the customer at the day-to-day operations level, ensuring a good communication and an improved understanding of how products are used and perform. Finally, field service networks are not only a key factor for providing after-sales services cost effectively, but also an opportunity for providing other services like overhaul or modernization.

Furthermore our findings suggest that the creation of a separate organization to handle the service offering by developing a dedicated sales force and a structure with dedicated service managers and technicians positively impacts the servitization over time. The change from a traditional to a servitized manufacturer required significant organizational changes in language, values, design process and organization design. A separate organization unit protected the emerging service culture with its metrics, control systems and incentives. It also seems to be easier to initiate service orientation in the corporate culture and therefore improving direct service profitability, the quality of customer relationships and the selling of more services over time. Today it also helps the manufacturer to diffuse knowledge across the network and to better manage the service personnel. The product-service combinations are less sensitive to price-based competition, and therefore provide higher levels of profitability in comparison to offering the physical product alone. The service margins in this company are clearly higher than product margins over time. Selling bundles of product-service tend also to be counter-cyclical or more resistant to the economic cycles that affect new elevator purchases. The ongoing service contracts and support activities provide a more stable revenue stream, which can smooth the effect of lumpy product sale revenues over time. Service contracts may only generate smaller revenues, but they are typically regular. Thus, by including more services in its total offering, the manufacturer tends to balance the effects of economic cycles with different cash-flows, since services tend to reduce the vulnerability and the volatility of cash-flows.Over the last ten years product revenues fell 50 percent, while service revenues increased more than 20 percent.

Strategically the manufacturing elevator company studied is further developing the installed base in order to sell more services. There is a very large installed base (that is increasing every year) and providing maintenance and support service through the entire product life (20 to 25 years) for the installed base represents a significant source for new service revenue streams.

A Hybrid List Scheduler and Tabu Search Heuristic for the Flexible Jobshop Scheduling Problem

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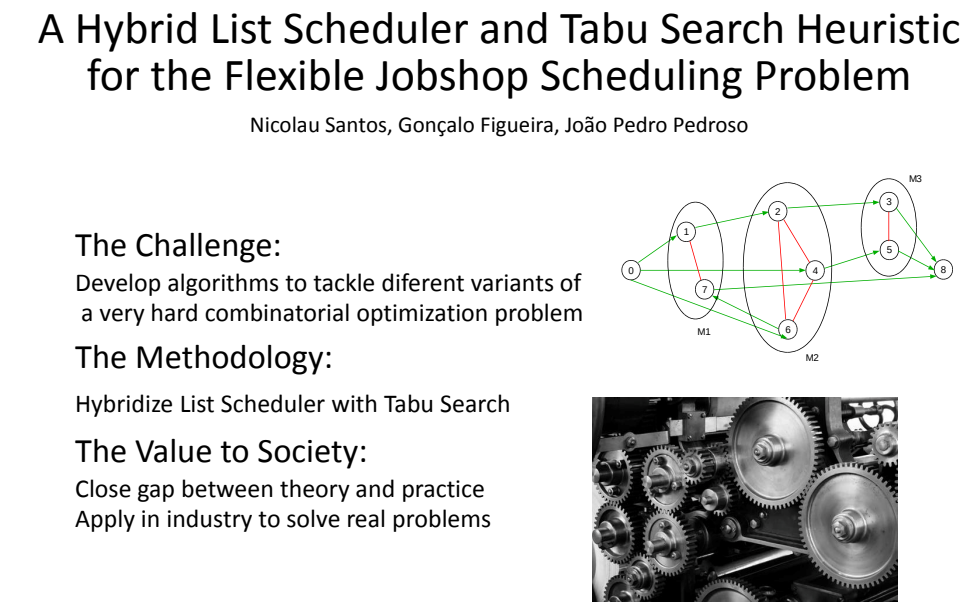

1 The Challenge

The Flexible Jobshop Scheduling Problem (FJSP) has a key role in the modeling and simulation of modern production systems. In the FJSP we have a set of n jobs to process in m machines. Each job is composed by operations that can be processed in one ore more parallel machines. The considered operations follow a specified sequence of technological operations and job preemption is not allowed. A given machine can only process a given operation and each operation can only be processed by a single machine. The objective is to find a feasible schedule of the considered operations that optimizes a given criteria. While a great attention has been given in the literature to the Makespan minimization, other considerations, such as minimization of Total Tardiness, Total Flowtime, inclusion of Sequence Dependent Setups or stock management are seldom seen. In this work we present an algorithm that is easily adaptable to different variants and considerations of the FJSP.

2 The Methodology

The proposed algorithm is based on one of the most simple methods to solve the FJSP: the list scheduler (LS). In the LS, at a given step we have the possibility to choose an operation from a candidates list. The chosen operation is afterwards scheduled and its successors are added to the candidates list. The process is repeated until all operations are scheduled. The choice of the operation to schedule is made according to a given criteria and there are many well know examples of application, such as the Shortest Processing Time rule (SPT) or Earliest Due Date rule (EDD). To mitigate the limitations of the greedy choice from the candidates list we restrict the number of candidates, according to a given parameter alpha, and we choose the operation to schedule randomly from the restricted candidates list. A posterior Local Search is included in Greedy Randomized Adaptive Search Procedures (GRASP), in order to further improve the obtained solutions. The main limitation of this approach is that the local search is tied to the considered objective function and the algorithm cannot easily be extended.

Tabu Search (TS) is an iterative metaheuristic developed to tackle very hard combinatorial optimization problems. At each step it analyzes a set of possible modifications to the current incumbent solution and moves to the best one, even if its objective its worst. The selection of the move to apply is conditioned by a tabu list, a structure that stores information of recent moves. The combination of these characteristics prevents TS from being trapped in a plateau and avoid cycling between iterations.

In this work we propose the hybridization of LS with TS, more precisely we use LS for Local Search itself: at each step we break the incumbent solution at a given operation and apply LS to construct the remainder of the solution. The process is repeated until a given number of iterations is reached. The main benefits of this approach are that the Local Search procedure becomes connected with the operation's choice and thus the adaptation of the selection rule for a different objective function will not require further modifications in the algorithm. The proposed approach is also easily adaptable for other problem characteristics, such as Sequence Dependent Setups or stock materials validation, and scales well for large problems with thousands of operations.

3 The value to Society

Although a lot of attention has been given to the FJSP the gap between theory and practice is still considerable. This is motivated by the fact that some of the developed algorithms rely on the characteristics (such as the swap of operations in critical paths to minimize the Makespan) and cannot be extended to other objectives. In this work we present a hybrid heuristic for the FJSP that is both adaptable to different different objectives functions and scales well for large problems. The main contribution of the work is to reduce the gap between theory and practice of the FJSP. The proposed approach is also under evaluation to improve the standard in a Decision Support System used in a printing shop plant.

4 Acknowledgments

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Robust Supply Chain Design under Supplier Integration and Consolidation Uncertainty: an Aerospace Case-study

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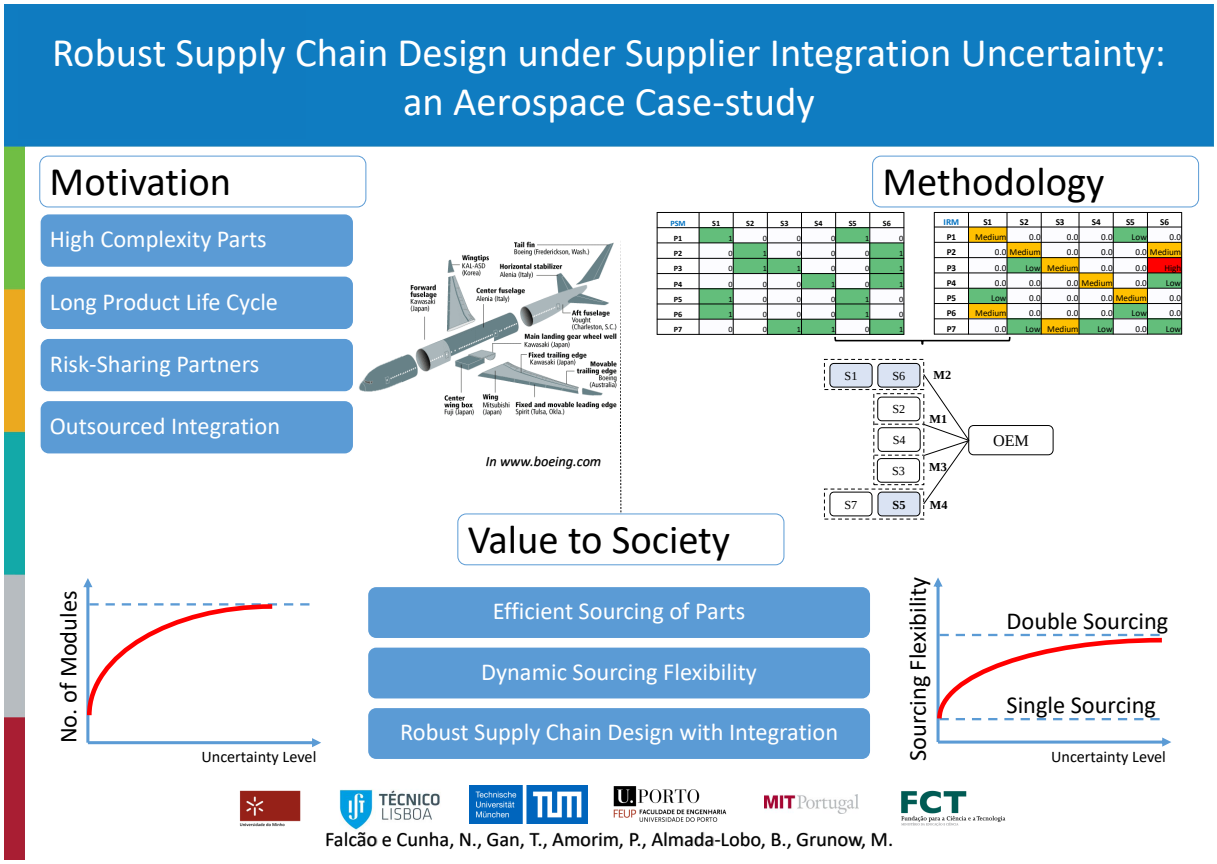

1 The Challenge

The aerospace sector is characterised by low production volumes with high degree of technological complexity, and long product life cycles that yield expensive aircraft development programmes. To ensure profitability, Original Equipment Manufacturers (OEMs) are forced to keep each aircraft in production for 25 to 30 years. The strategic planning of their supply chains and product portfolio plays a key role in the success of these companies.

The catastrophic events of September 11 highlighted the need for robust risk mitigation strategies as the entire industry was driven into a recession. To recover market trust, airline providers were forced to lower their prices. As a result OEMs such as Airbus, Boeing and Embraer have since been pressured to reduce purchase and operating costs for their aircraft. This has motivated new, more efficient, aircraft generations using innovative technologies, such as composite materials. To support these technological

advancements, aerospace supply chain management practices also had to evolve. OEMs developed more global supply chains, increasing the amount of foreign sourcing, and adopted risk-sharing partnerships with key suppliers.

With the intent of lowering costs across the entire supply chain and in order to reduce their exposure from the large investments in aircraft development programmes, certain suppliers were selected to take responsibility for part of the costs and risks. This strategy has been aggressively pursued by Airbus and Boeing, as partners have had to absorb most of the non-recurring costs involved in developing aircraft, and only begin to recuperate their investment after first sales. As a result, OEMs have since assumed the role of systems integrators and passed on considerable product design, development and manufacturing responsibilities to their suppliers. Some of these suppliers began to keep the Intelectual Property (IP) for the systems and components that they provided.

Suppliers thus had to develop their technical capabilities and OEMs began to outsource larger and more complex components of their aircraft, aiming to reduce final assembly times. The Boeing 787 Dreamliner was the biggest step in this direction, with 70% of aircraft components being outsourced and final assembly time being reduced to 3 days. Boeing hired 50 tier-1 partners that took on the role of "Integrators" and were required to deliver complete sections of the aircraft. However, the 787 programme was threatened by many problems which led to a 200% increase in development costs and schedule overrun, as some suppliers were unable to consistently fulfil their obligations. Boeing's inclusion of some unproven technologies in the 787, such as new composite materials, meant that some suppliers did not have the technical capabilities to integrate their sections. Additionally, some partners were unable to manage their own supply chain and accurately track the performance of their own suppliers.

As more responsibility has been passed on to key partners, there has also been a consolidation wave between Tier-1 aerospace suppliers. Mergers have been one of the strategies for these companies to become resilient and to acquire certain technical capabilities. While suppliers must not be disrupted over the entire duration of the aircraft programmes, these actions may lead to the loss of planned redundancy in the OEM's supply chain and may lead to an increase in the overall supply chain risk.

The shifts in responsibilities, and the further consolidation of Tier-1 suppliers increase their decision power within current and future aircraft programmes. As a result, the power relationship between the OEMs and the "Super Tier 1 Suppliers" is a relevant and current topic. On one hand, OEMs acknowledge the potential for new procurement synergies with greater systems integration, price bundling, and risk pooling. On the other hand, they may face the loss of negotiation power and Intellectual Property.

2 The Methodology

In this research, we study the design of aerospace supply chains and supplier selection for new aerospace products. We develop a supply chain design (SCD) method that seeks an efficient and robust supply base with minimum number of supplier modules. Supplier modules contain the supplier, or group of suppliers, from which a set of parts is sourced. This model considers the risk associated with each of the suppliers selected. It will mitigate supplier modules that exceed certain risk thresholds, which are defined by decisions makers with different risk aversion. The model further allows for distinct selective sourcing flexibility for each module as a potential risk mitigation strategy.

One of the necessary inputs for this model is the pool of supplier candidates, which is represented in a Part-Supplier Matrix (PSM). The PSM contains a binary relation between parts and suppliers, and indicates whether the part can be sourced from a certain potential supplier. The corresponding integration risk for a supplier to integrate a given part is represented in the Integration Risk Matrix (IRM). The IRM evaluates this risk through 3 risk-levels: 'low', 'medium' or 'high'. Finally, the propensity for merger between each supplier pair will be represented in a Consolidation Risk Matrix (CRM). The CRM uses the same scale as the one in the IRM. Traditionally, OEMs perform their own estimations for these risks based on their knowledge of the suppliers' operations, their technical and supply chain management capabilities, and their financial condition. Portfolio similarity, or complementarity may also be taken into account when estimating the consolidation risk between two suppliers.

Robust optimization (RO) is used to investigate how decision makers may design their supply chains to mitigate the integration and consolidation risks described in the previous section. RO is used to test the effects of uncertain integration and consolidation risks on the SCD and the selection of suppliers. By introducing varying uncertainty levels into the initial risk assessment, it will be possible to study their impact on the SCD. We will study they affect the size of supplier modules, as well as the optimal sourcing flexibility. In practical terms, scenarios produced through higher uncertainty levels represent more pessimistic scenarios, meaning that the suppliers' performance deviated considerably from the original assessment.

We will use real data from one of Airbus's supply chain design projects as a case study. Using our integrated robust supply chain design method, we will analyse the efficiency of the original allocation of parts to suppliers, as well as the robustness of the chosen SCD.

3 The Value to Society

The Aerospace Sector has changed considerably in the wake of catastrophic events and OEMs have adapted both their products and supply chains to respond to market pressures. This rapid evolution has led to a series of sources of uncertainty that must be considered in the design of supply chains for new aircraft programmes. OEMs are prioritizing the reduction of final assembly times and have requested larger sections to be integrated by key suppliers.

Supply Chain Design under supply chain risk management has been vastly explored by academia. The existent literature describes various methodologies to analyse sources of uncertainty for different industries. The contribution of this paper is threefold: first, it addresses an undocumented industry within the scope of Operations Management. Second, it studies emerging sources of risk which have led to unforeseen expenses and delays in recent aircraft programmes. Third, it employs a unique approach that combines robust optimization with a SCD, in an integrated methodology.

The goal of this research is to make aerospace SCD more robust towards emerging sources of risk. The conclusions drawn from this research will support decision makers in designing supply chains for future aerospace products that mitigate the uncertainties that threatened previous programmes. Despite the motivations behind this model coming from the aerospace industry, it can be extended to other industries with comparable technological complexity and product life cycles.

We model the trade-off between supplier modularity and integration risk. We analyse how the risk aversion of OEM decision makers affects the robustness of SCD. We model propensity for merger between key suppliers and the impact of these decisions on the supply chain. Robust optimization is used to investigate how supplier modules should be assembled to achieve stable SDC. We propose strategies to mitigate integration and consolidation risks is studied through different levels of sourcing flexibility and by adjusting the integration assigned to supplier modules.

A Genetic Algorithm for Balancing and Sequencing Mixed-model Assembly Lines

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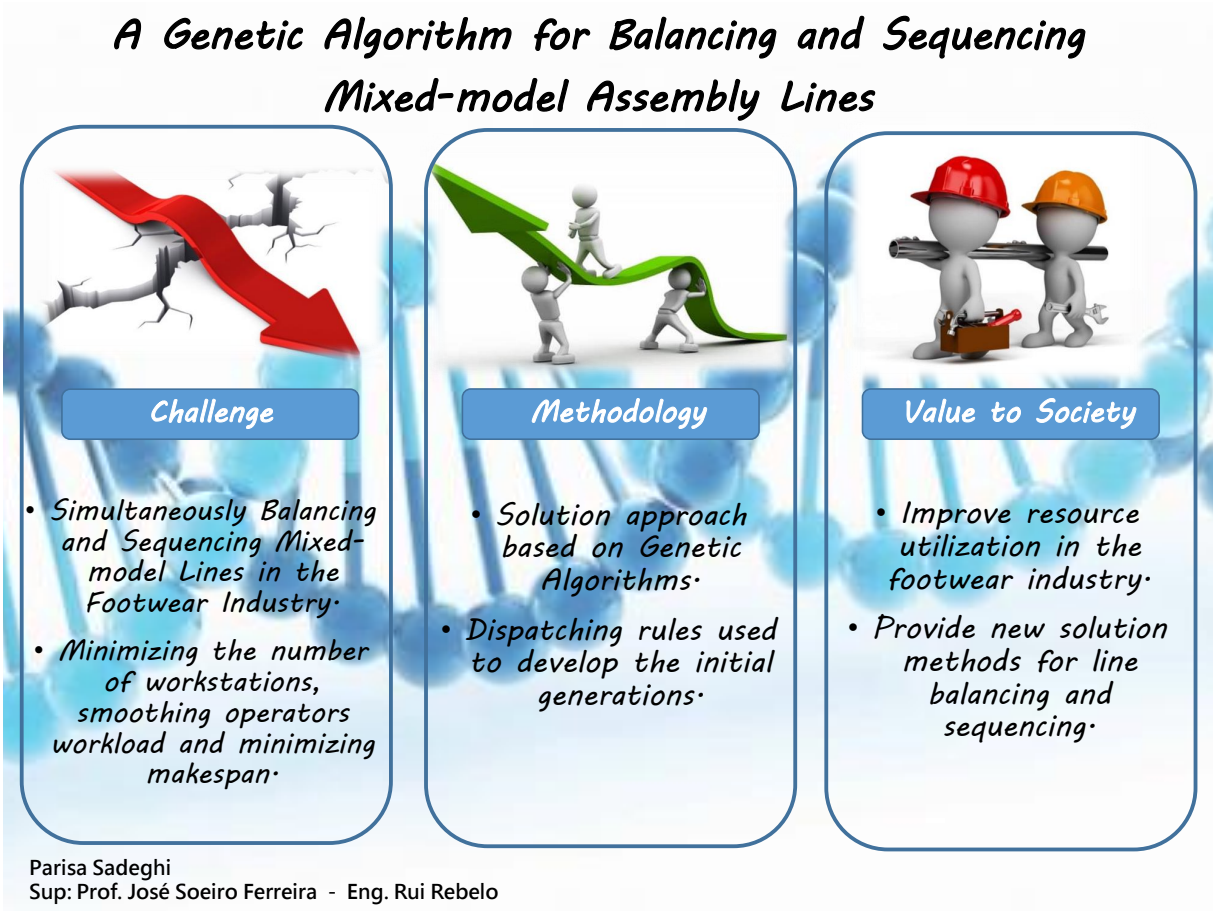

1 The Challenge

In this work we aim at developing a new solution approach for balancing and sequencing mixed-model lines in the footwear industry. In producing footwear various processes are involved such as cutting, stitching and assembly. This work focuses on the stitching lines of a Portuguese company. Footwear components move inside boxes (in various quantities) along flexible automatic transportation systems, allowing each box to move from the warehouses to any convenient workstation or between any workstations. A workstation consists of an operator and a machine. There are two different stitching systems, each in a separate place of the factory (depicted in the Figure). The larger one comprises four parallel lines with the machines facing a transporter and the smaller system having a "U" shape.

The footwear industry nowadays produces many distinct models, which also change according to the season. People's behavior also changed leading to a decrease in the number of orders per model. As a result, it is fundamental to have several models in the production lines simultaneously. To produce a pair of shoes, it is essential to divide the work needed into a set of tasks. Each task requires a certain

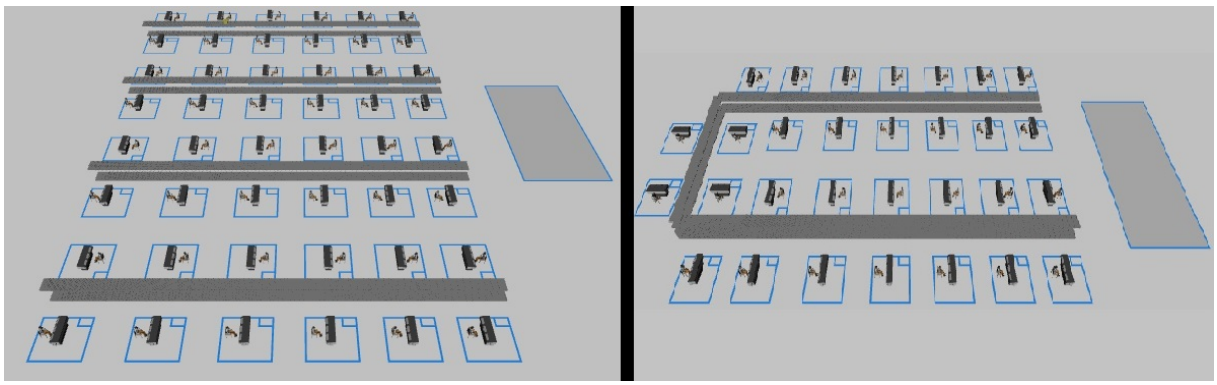

Figure 1: Different Systems of Stitching Lines.

processing time. Additionally, each model has a special production routing that increases the difficulty of the balancing and sequencing processes. The associated balancing and sequencing problems (here considered simultaneously) are usually known as Mixed-model Assembly Line Balancing and Sequencing Problems (MALBSP).

The assembly systems integrate new transportation equipment that will only be effective if it is well managed. These days, MALBSP in the factory is solved manually and by using experiments, so having a system supported automatically is necessary. Given that production plans change rapidly, it is crucial to know the number of operators and machines required. This study essentially focuses on balancing resources, conveniently allocating tasks to workstations so that operators' work time becomes approximately the same and reducing the completion time, as much as possible. These objectives were chosen after discussions with the managers of the company.

Line balancing takes into consideration the operators' skill levels. This means that it is important to assign an adequate operator to the right task. There are special operators in the company who are the only ones with the ability to perform some tasks and, therefore, these tasks should be pre-assigned to those specific operators. Machines must be allocated to workstations, and they are classified according to various types depending on their capability to carry out certain tasks.

Moreover, defining a convenient sequence of the tasks on the workstations is another value of this work, as it may decrease the completion time.

2 The Methodology

A good line balance solution in this work should open a reduced number of workstations, in a way that the right operators and machines are assigned to the correct tasks and the operators' workloads are balanced. Besides a good sequence should reduce makespan as much as possible. These objectives are translated into the objective function of an optimisation model. Due to the large dimension of the real problems, the model developed could not be solved. However, it has been useful for better understand the problems under study and to analyze small instances.

The solution approach proposed is based on Genetic Algorithms (GA) and resorts to a special constructive heuristic to generate initial populations. Preliminary boxes with the maximum amount 10 are created, by considering the production order of available models. Then, their entrance order is defined, based on different dispatching rules, which are generally used for minimizing the makespan. The constructive heuristic generates 40 diverse initial solutions.

A part of the solutions (20) is created considering the Largest Number of Successors (LNS) rule and 20 other solutions are created based on the Critical Path (CP) rules. Moreover, after creating one solution the sequence of operators in the input data is changed in a way to generate a new diverse solution. If 40 different solutions are not obtained then other dispatching rule, Longest Processing Time (LPT), first is

applied.

The chromosomes are designed to include three elements, the first is an artificial number which is related to a task of a model of a box, the second is an operator number and the last is a machine number to which the task was allocated. Crossovers and mutations are applied taking into account sequencing and allocation. More details are presented below:

1. A two point's crossover is used for the first crossover. The task of each parent in the selected point is transferred to each child, in the same point. Precedence preserving rule is used to avoid infeasibility. The other tasks of each child are the same as the other parents which are not used before in this child;
2. A two point's crossover is also used for the second crossover. Each child is a copy of a parent. However, the difference in each child relates to the assignment of the tasks: which tasks between two points are assigned to operators and machines from the other parent;
3. In the first mutation a solution and two points are chosen; then the sequence of the tasks between two points become inverse but again the rule of precedence preserving is applied in a way to avoid creating an infeasible solution;
4. In the second mutation which specially takes into consideration allocation, the tasks are the same but the operators and machines between two selected points become inverse. This inversion for each element of a chromosome could be done, if the solution is still feasible.

The fitness evaluation is based on the objective function that includes three parts with different weights. They are the number of needed workstations, smoothing functions representing operators' workload and the third part is the makespan. The algorithm runs 50 iterations.

3 The value to Society

This work focuses on real world MALBSP. Balancing and Sequencing are treated simultaneously, what is not so common in the literature. Therefore, it may contribute both to the field of Line Balancing and Sequencing and to real applications.

It should also be mentioned that quite new automated systems, specially designed for the footwear companies, are now being installed. Until now, these systems have been managed manually, following operators' experience. Therefore, there is a strong need for optimisation systems, which can offer good and fast solutions and help the specialised operators to manage the lines. Generic parameters which are used in this work make it useful for other similar industries, consequently the solution method and the problem are not just for the footwear industry.

A methodology for evaluating the evolution of social performance of mining firms

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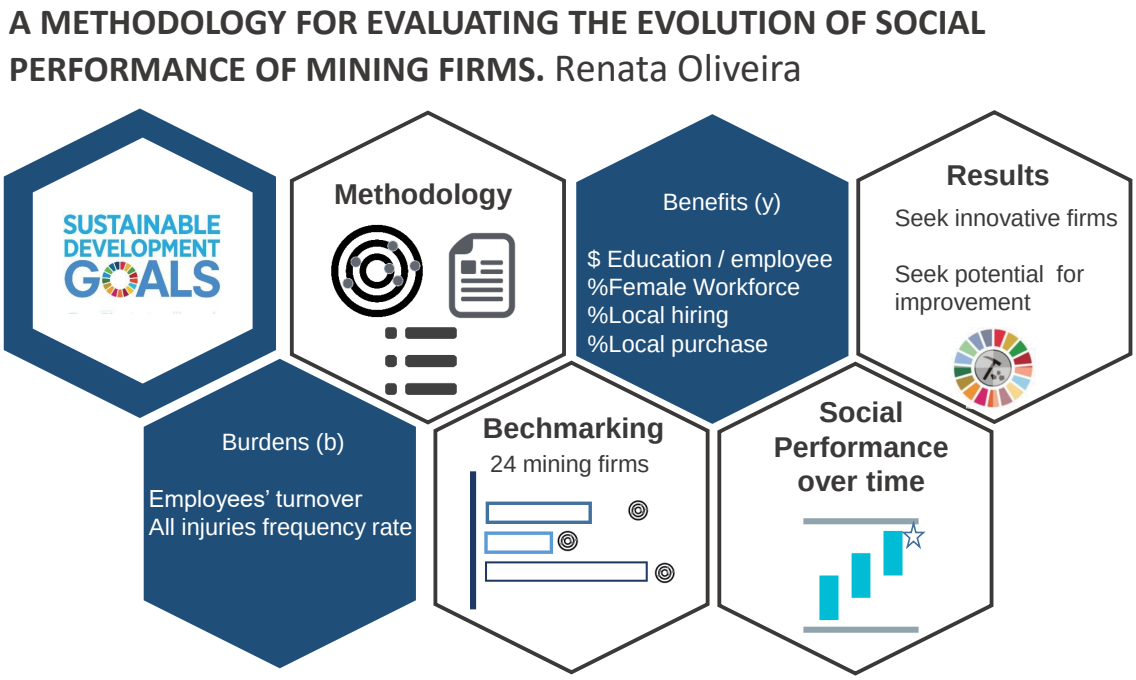

1 The Challenge

This study proposes a methodology for evaluating and monitoring the evolution of social performance of large mining firms over time. The mining sector has been acknowledged by the United Nations as an industry capable of boosting the implementation of the Sustainable Development Goals (SDGs) in development countries by 2030. However, there are a few challenges associated with the estimation of a quantitative measure of social performance. The first challenge is that the contribution of mining firms to social development at local level is considered controversial due to historical disruptions caused by mineral exploitation in communities and eco-systems. The second challenge is that, although there is a body of research on the monitoring of Corporate Sustainable Development (CSR) practices, frequently referred as Corporate Social Responsibility (CSR), social issues (e.g., decent work, local development, gender equality) are often overshadowed by economic and environmental themes (e.g., value-added, air emissions). The third challenge is that most of the approaches used to evaluate social performance rarely take into account quantifiable criteria. The fourth and last challenge regards defining a benchmarking framework reflecting both desirable and undesirable factors, whose balance can unveil the overall contribution of these firms to society and indicate improvement opportunities.

2 The Methodology

The methodology proposed in this research is composed of three parts. The first part regards the construction of a framework of Key Performance Indicators (KPIs) comprising both desirable (benefits) and undesirable factors (burdens) that are relevant for evaluating the social performance of large mining firms (see Table 1). The KPIs selected reflect quantifiable social criteria recommended in international standards (e.g., the International Organization for Standardization -ISO 26000:2010) and sectorial guidelines (e.g., 10 principles of the International Council on Mining and Metals-ICMM).

Table 1: Framework for evaluating social performance

Desirable (y): benefits	**Undesirable (b): burdens**
Investments in education per employee (y_1)	
Female workforce ratio (y_2)	Employees' turnover ratio (b_1)
Local hiring ratio (y_3)	All injury frequency rate (b_2)
Local purchase ratio (y_4)	

The second part is based on the specification of an optimization model, shown in (4), for estimating a composite indicator (CI) of social performance. This research adopted the CSR management perspective of creating benefits to society instead of exclusively pursuing being harm neutral. Therefore, the CI model (4) searches for potential improvements in the levels of benefits KPIs defined or reductions in the levels of burdens.

$$
\begin{aligned}
& \vec{D}(1, b, y; 0, g_{b_{ik}}, g_{y_{rk}}) = \max \beta_k \\
\text{s.t.} \quad & \sum_{j}^{n} \lambda_j b_{ij} \leq b_{ik} - \beta_k g_{b_{ik}} && i = 1, \ldots, m \\
& \sum\nolimits_{j}^{n} \lambda_j y_{rj} \geq y_{rk} + \beta_k g_{y_{rk}} && r = 1, \ldots, s \\
& \sum_{j}^{n} \lambda_j \leq 1 && j = 1, \ldots, n \\
& \lambda_j \geq 0
\end{aligned}
\tag{4}
$$

In formulation (4), b_{ij} are the undesirable KPIs, corresponding to social burdens (i= 1, . . . , m), and y_{rj} are the desirable KPIs, corresponding to social benefits (r= 1, . . . ,s). Similarly, b_{ik} and y_{rk} are the burdens (i= 1, . . . , m) and benefits (r= 1, . . . ,s) observed in firm k under assessment. The directional vector $g = (0, g_{b_{ik}}, g_{y_{rk}})$ is specified to search for improvements focusing on a selected set of KPIs.

The third part of the methodology regards the use of the Malmquist Index ($M^{t,t+1}$) for the assessment of social performance change over time. The Malmquist Index is based on ratios of Shephard's distance functions (efficiency measures), which are either input or output-oriented. The objective function of the CI model (4) estimates a directional distance function (an inefficiency measure), instead of a Shephard's distance function. Therefore, as a methodological contribution, this study reformulated the Malmquist index, so that it can be computed using inefficiency measures. This research also demonstrated how the Shepard's distance function can be obtained from CI formulations. The reformulated Malmquist index can be obtained by using expression (5), for a directional vector specified as $g = (0, 0, g_{y_{rk}})$.

$$
M_o^{t,t+1} = \left[\frac{1 + \overrightarrow{D}^{t} \left(1, {b_{ij}}^{t}, {y_{rj}}^{t}; 0, 0, {y_{rk}}^{t}\right)}{1 + \overrightarrow{D}^{t} \left(1, {b_{ij}}^{t+1}, {y_{rj}}^{t+1}; 0, 0, {y_{rk}}^{t+1}\right)} \; \frac{1 + \overrightarrow{D}^{t+1} \left(1, {b_{ij}}^{t}, {y_{rj}}^{t}; 0, 0, {y_{rk}}^{t}\right)}{1 + \overrightarrow{D}^{t+1} \left(1, {b_{ij}}^{t+1}, {y_{rj}}^{t+1}; 0, 0, {y_{rk}}^{t+1}\right)} \right]^{1/2} \tag{5}
$$

The values estimated for the $M_o^{t,\ t+1}$ with formulation (5) can indicate social performance growth, stagnation or decline between t and $t + 1$, corresponding to scores that are, respectively, greater, equal and smaller than one. This index can be further decomposed into an efficiency change index ($E_o^{t,t+1}$) and a technological change index ($T_o^{t,t+1}$), such that $M_o^{t,\ t+1} = E_o^{t,t+1} \times T_o^{t,t+1}$. Enhancements in the efficiency change component are evidence of catching up to the frontier, while enhancements in the technological change component indicate frontier shift between t and $t + 1$.

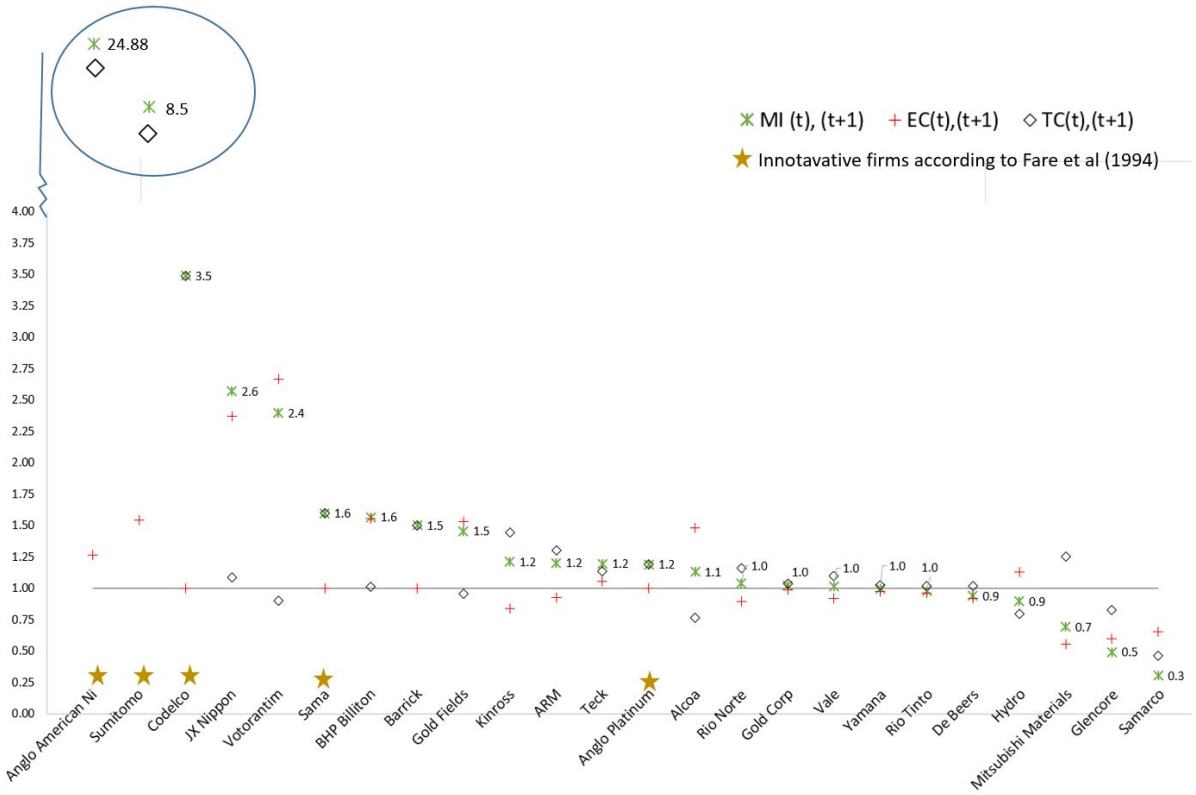

Figure 1: Classification of firms according to performance change over time

Regarding the application, a dataset of 24 large mining companies was assembled with data published by the Global Reporting Initiative (GRI) and corporate financial reports with external assurance of information. The data collection relied on reports published between 2012 and 2014. The reference years for the assessment are 2011 and 2012 as these are the most recent years available with the smallest number of missing values. All missing values in the sample were replaced by the worst observed value for each indicator. This approach is standard in assessments involving models based on Data Envelopment Analysis (DEA), and it was meant to ensure the firms' performances were not benefited unduly by the lack of information.

The results obtained are reported in Figure 1, where the firms studied are listed in decreasing order according to their change in social performance over time. The five firms marked with a star were classified as innovative, meaning that these firms were leading the best social practices of the sector between 2011 and 2012. Fourteen firms have showed evidence of performance improvement with scores higher than one. Five firms demonstrated signs of stagnation in social performance and other five firms achieved scores lower than one, meaning that they have worsened their social practices between years 2011 and 2012.

3 The value to Society

This study presented three main contributions to society. The first contribution was the identification of KPIs for the assessment of social performance that are aligned with the criteria requirements for the mining sector (e.g., local development and decent work). The second contribution was the development of a methodology for the quantification of the social performance at firm-level. The CI proposed can support benchmarking procedures for enhancing practices for creating social benefits from mineral exploitation. The third contribution was the reformulation of the Malmquist index, based on the values of the objective function of composite indicators estimated with a Directional Distance Functions.

The insights provided by this methodology include the acknowledgment of the best firms in the sector,

showing evidence of innovative practices, as well as the firms with potential for improvement. Finally, the methodology proposed was illustrated in the context of a comparison of mining companies operating worldwide, but it can be generalized to other sectors, or to comparisons of companies from different industries within a given geographic region.

Acknowledgements

This work is financed by the ERDF – European Regional Development Fund through the Operational Programme for Competitiveness and Internationalisation – COMPETE 2020 Programme within project "POCI-01-0145-FEDER-006961", and by National Funds through the Portuguese funding agency, FCT – Fundação para a Ciência e a Tecnologia as part of project "UID/EEA/50014/2013". Thanks are due to CAPES for funding this work through the Program Science without Borders (BEX 19131127). Thanks are also due to University of Para State (UEPA).

A vehicle routing problem with multiple synchronisation constraints: application in the biomass supply chain

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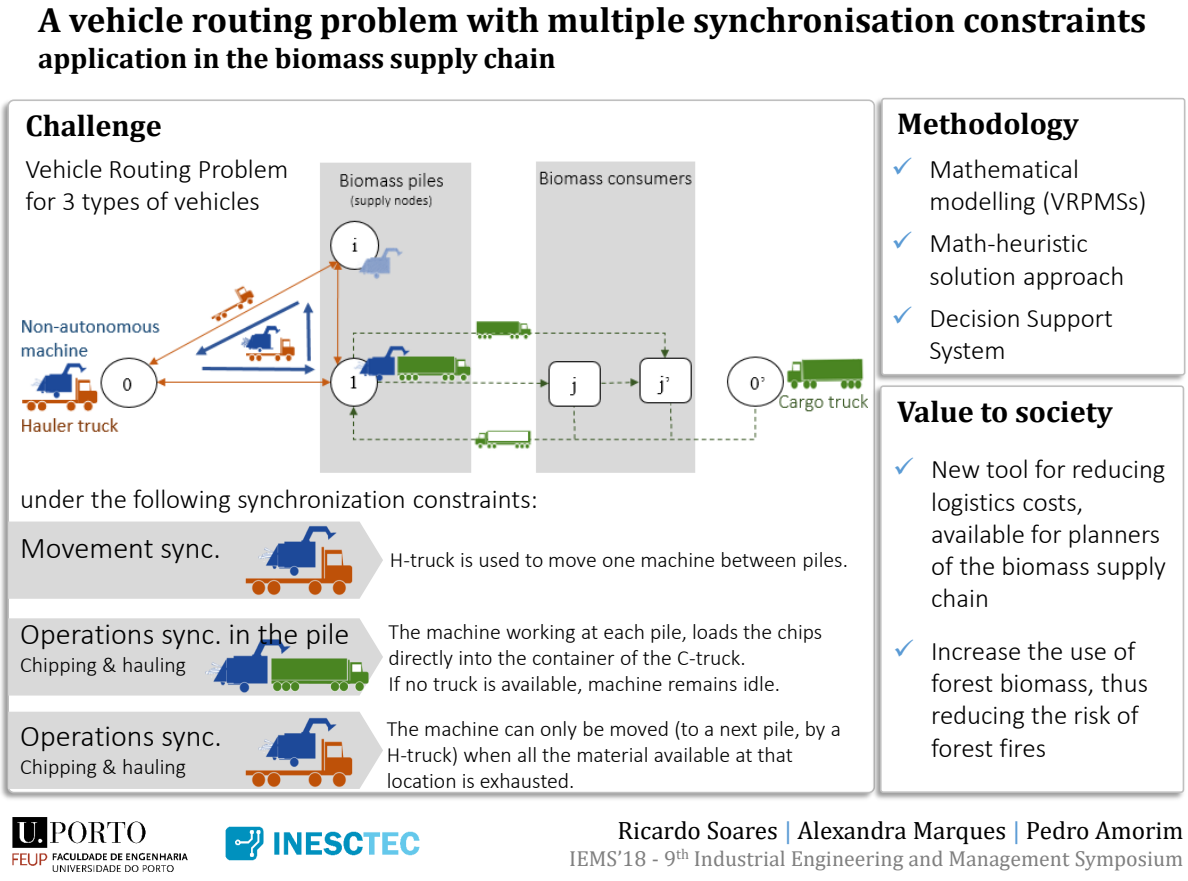

1 The Challenge

This work addresses the integrated routes planning for three distinct types of vehicles that need to be synchronised to perform interrelated operations with minimum logistics costs. This planning problem exists in the biomass supply chain and specifically relates to the synchronisation of vehicles involved in wood chipping and transportation when these operations are combined at the roadside of forest sites (called "hot systems"). It is a particular case of Vehicle Routing Problems with Multiple Synchronisation Constraints (VRPMSs) found in the literature, with the novelty of considering both movement and two-level operations synchronisation, as illustrated in Figure 1. The optimal planning of chipping-transportation operations is crucial to make existing value chains cost-efficient and competitive in respect to the alternative fossil fuels.

Synchronization aspects are very important when planning the biomass logistics because it can shorten

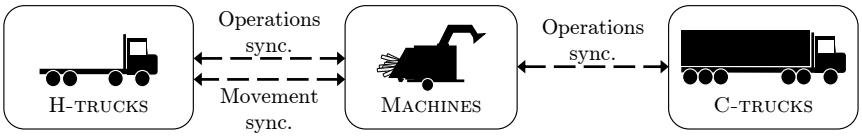

Figure 1: Overview of the vehicles and synchronisation aspects addressed in the problem

the duration of transport and handling operations, reduce the number of vehicles needed and use them in a more efficient way by minimizing the trucks' waiting time, the chipping machines' idle time and the overall transportation costs. The three distinct types of vehicles whose routes need to be synchronised are:

1. trailer-mounted machines (henceforth called machines), that perform an operation (e.g. container loading) at a given location and cannot move autonomously. In the biomass chain, chipping machines are fixed to a biomass pile at the roadside and process forest residues directly into a chargeable container;
2. the cargo trucks (here called C-trucks), which perform interrelated operations (e.g. container loading and transport) that need to occur at the same time and location as the first one. In the biomass chain, the chargeable container is mounted in a C-truck, transporting it up to the biomass centrals;
3. the hauler trucks (H-trucks), responsible for transporting one machine at-a-time between locations. In the biomass chain, H-trucks transport machines between the roadside biomass piles spread along a region.

The relevant synchronisations aspects under study are illustrated in Figure 2 and are:

1. Movement synchronisation (MS) between the H-truck and the machine: These vehicles should perform equal routes while moving between the locations (i.e. biomass piles) spread along a region.
2. Operations synchronisation (OS) between the H-truck and the machine: The loader can only be moved when all the material available in that location is exhausted.
3. Operations synchronisation (OS) between the machine and the C-truck: both types of vehicles should be present at the same time and location so that the interrelated operations can occur. The machine serves one C-truck at a time until its container is full, so other C-trucks need to wait for the machine to become available. The machine remains idle if no C-truck is available at that location.

2 The Methodology

A Mixed Integer Programming (MIP) model is developed for solving this problem. The approach consists in considering three Vehicle Routing Problems (VRPs), one for each type of vehicle, which are intertwined with synchronisation constraints in order to ensure the problem's requirements. This adopted modelling approach requires that fictitious locations be considered, which will be associated with a real-world location, and are necessary in order to distinguish different operations performed in the same location.

Although a single VRP may already be computationally expensive, let alone three, not all types of vehicles visit the same types of locations. Therefore, many incoherent possibilities of the transportation network are eliminated in a pre-processing stage, which not only allows to substantially reduce the problem's size, but also allows to implicitly model some of the synchronisation aspects, thus avoiding the addition of certain synchronisation constraints.

Due to the combinatorial nature of this problem and of VRPs in general, exact solution methods for this problem are only adequate for small scale instances. For large scale instances, the solution approach requires alternative methods, such as math-heuristic methods (e.g. fix-and-optimise). Results from a real-world problem of a Finnish biomass supplier are analysed, and interfaces with the purpose of supporting decision making are also developed.

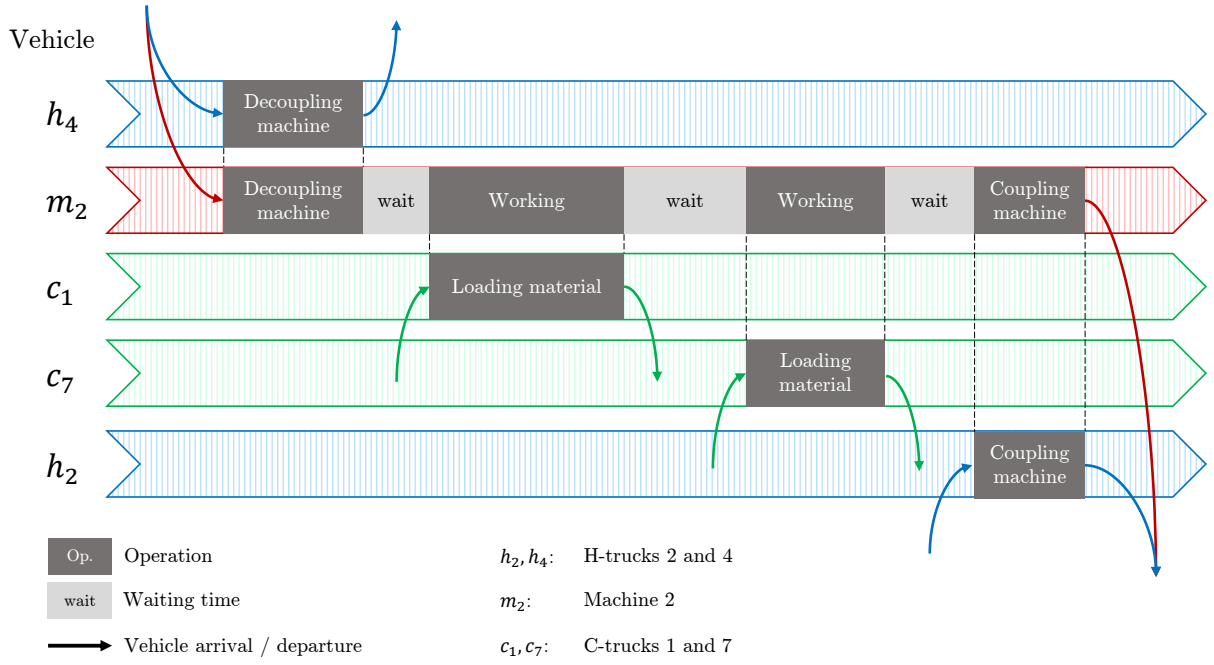

Figure 2: Timeline representing inter-vehicle synchronisation at residue harvest piles

3 The value to Society

Design and planning of Biomass-for-Energy Supply Chains (BESC) has been widely studied, as society reinforces the major role of biomass as a global primary energy source. In the case of woody biomass (produced from branches and other by-products of forestry operations), as in other forms of biomass (e.g. residues from agriculture, forestry, fisheries and municipal waste), the availability is temporally and geographically fragmented, which makes it particularly relevant to find cost-effective solutions for biomass production, storage and transportation up to the consumption facility. One of the key challenges in forest-based supply chains is reducing its logistics costs, as they typically represent 30% to 50% of the cost of the finished products. This issue, along with the fact that products in the forest industry tend to have very low margins, leads to the constant need for efficiency in the supply chains' operations.

This research work frames itself in a doctoral programme and in ongoing research projects at INESC TEC: EasyFlow ("Collaborative and efficient logistics towards more sustainable forest supply chains"), BIOTECFOR ("Biobusiness and Technology for the efficient valorization of endogenous forest resources in the North of Portugal and Galicia") and GOTECFOR ("Technology for the mobilization and use of Forest Biomass in agro-industry").

Retail Distribution to Brick-and-Mortar Stores

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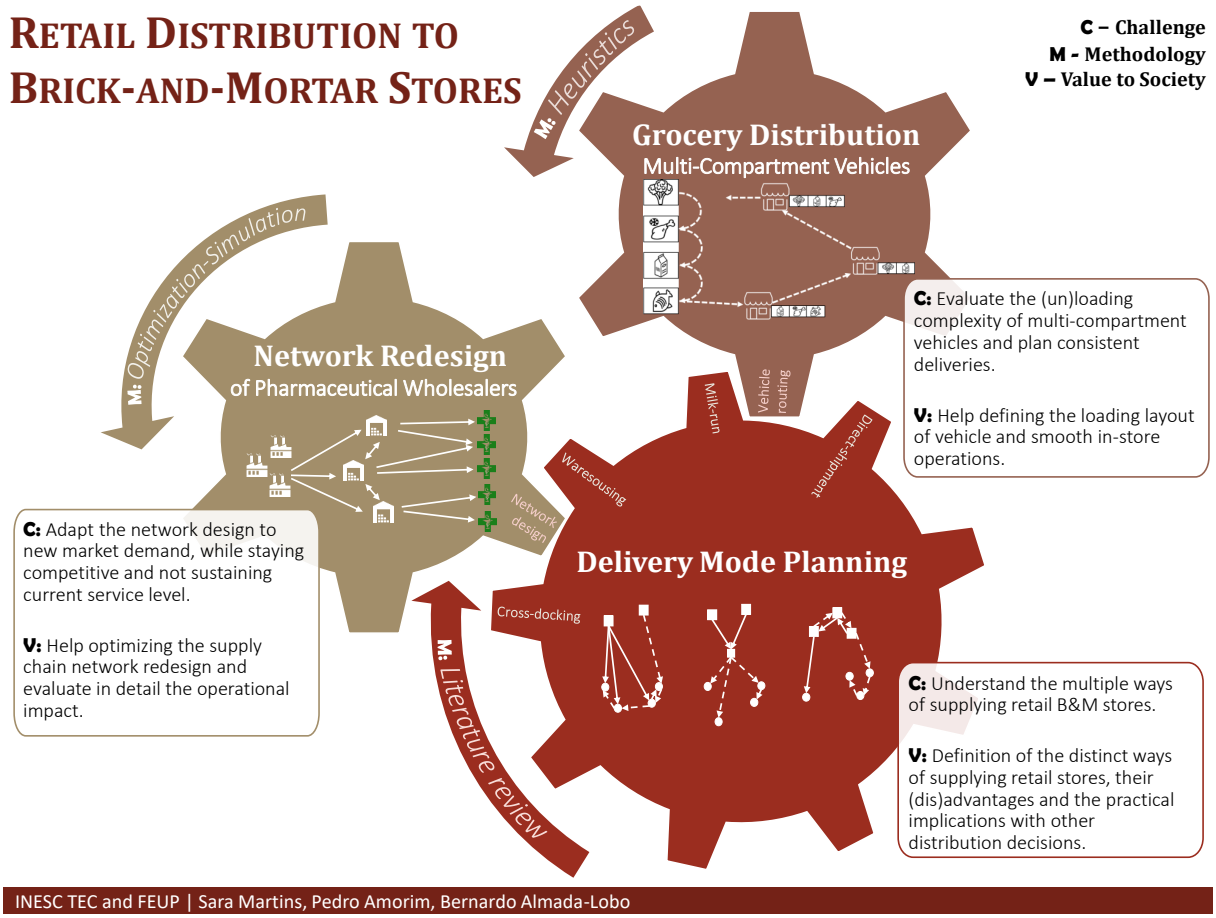

1 The Challenge

The retail sector is changing and new paradigms are emerging for the distribution process. This work focuses on some of the new challenges the pharmaceutical and grocery retail sectors face and aims to understand how retailers can adapt their distribution activities to stay competitive. This work tackles the particular problems regarding redesign of the supply chain network and the distribution planning with multi-compartment vehicles.

Despite the fact that customers are able to interact with retailers through different channels, the brick-and-mortar (B&M) stores remain the main channel for shoppers. The distribution between distribution centers and B&M stores can be planned according to different distribution strategies. It is important to understand the distinct types of delivery modes that can be performed to supply the B&M stores, their advantages and disadvantages and the practical implications with other distribution decisions.

The network design of a supply chain can leverage distinct types of delivery modes depending on how it is defined. We analyze this design decision in the context of the pharmaceutical sector, where the

distribution to the pharmacies is performed by wholesalers. We focus our study on the network redesign of pharmaceutical wholesalers in order to respond to the new market demand, while staying competitive and not jeopardizing the current customer service level. In this sector, pharmacies are struggling to survive, due to the economic crisis, and are changing their purchasing behavior to smaller and more frequent orders. While the network design is extensively studied in the literature, few works consider the redesign variant and take into consideration the response time indicator, besides costs. The response time is a key driver in this sector because different wholesalers can satisfy the pharmacies demand, as there is no cost or legal bound for switching between wholesalers.

On another stream, distinct types of vehicles impose different limitations to the way the distribution is performed. Naturally, the type of vehicle can restrict the types of delivery modes that can be chosen. In the retail industry the transportation of products between distribution centers and stores is normally ensured by trucks, which are traditionally differentiated in the literature by their capacity. Another distinction that can be made concerns the number of compartments in one vehicle. We study the incorporation of multi-compartment vehicles in the grocery distribution planning. In the last years, multi-compartment vehicles, which enable the physical separation of products during transportation have been deployed. This type of vehicles are increasingly being used by grocery retailers to perform mixed product distributions. The few works on grocery distribution with this type of vehicles only target the routing decisions and their operational impact on distribution centers and stores. The complexity of the loading/unloading process with these vehicles has never been studied. Therefore, we propose extensions of the routing problem to consider the impact of loading constraints.

Furthermore, grocery stores usually define preferable time-windows to indicate when deliveries should occur. Stores do need to align their operations to the delivery schedule to make sure their resources are available for unloading, replenishment and stocking operations. These activities impact staff scheduling and backroom capacity planning. Therefore, delivery times have to be pre-defined and fixed for a given period to efficiently coordinate store resources during the day, which leads to consistent deliveries throughout the planning horizon. The definition of the time-windows impacts the possible mixed distributions. To incorporate this feature, we also extend the routing problem with time-window assignment decisions.

2 The Methodology

To tackle the network redesign problem of pharmaceutical wholesalers an optimization-simulation approach is proposed. In a first-phase, at a strategic-tactical level, the network redesign decisions are optimized using a mixed integer programming model. This model optimizes the number, location, function and capacity of the warehouses, as well as customer allocation, in order to minimize the total costs (warehouse and transportation costs). In a second-phase, the operation of the supply chain is simulated by means of a discrete event simulation model to assess the new network design from an operational perspective, specifically the service level in terms of lead time.

In the study of the grocery distribution with multi-compartment vehicles, we first focus on the inherent routing problem and incorporate the loading constraints. We use a large neighborhood search heuristic with two operators, which destroy and rebuild parts of a solution to improve it. In this problem, we decide for each vehicle the orders assigned, the number and size of compartments and the sequence of store visits. The solution approach also includes a repair mechanism, which is a packing problem, that defines how the compartments should be organized, and what orders should be assigned to them, in order to avoid loading problems. In a second phase, we extend the multi-compartment vehicle routing problem by considering a multi-period setting with a product-oriented time-window assignment. This problem adds to the routing decisions the definition of a unique time-window for each product-store pair that should be used consistently throughout the planning horizon. Since time-windows are not a hard-constraint in practice, because stores still accept earlier or late deliveries with a negative impact on store operations, we chose to consider a penalty cost for delivering outside the time-windows that adds to the routing cost. To solve this problem, we extend the previous heuristic approach to consider more operators that tackle different decisions of the problem. We developed daily operators to improve the routing of each day, and weekly operators to align the time-window assignment consistently throughout the planning horizon.

3 The value to Society

In this work, we analyzed different extensions of the distribution problems that emerge in different retail sectors.

With regard to the pharmaceutical sector, the response time indicator is a crucial indicator of a wholesaler performance and therefore should be carefully analyzed when defining a new supply chain design. For businesses in which the details are critical and very time sensitive, such as the pharmaceutical distribution, the hybrid approach of integrating optimization and simulation allows to obtain accurate and robust solutions. The models proposed were implemented by a Portuguese pharmaceutical wholesaler and helped them to optimize their supply chain network design and evaluate in detail the operational impact of implementing a new configuration. Furthermore, the advantages of performing cross-docking operations for deconsolidation of orders were highlighted.

Concerning the grocery distribution, the use of multi-compartment vehicles allows to perform mixed distribution of products. Instead of performing separate tours for products with distinct temperature requirements, visiting a store multiple times a day, with these vehicles a single visit with the full range of products can be performed. However, the multi-compartment vehicles impose additional challenges than the normal single-compartment vehicles. While in the latter orders just needed to be loaded in the reverse way of the tour, in the former, the organization of the compartments needs to be defined respecting additional requirements. The packing problem proposed can be used by companies to help defining a feasible loading layout, if such is possible, or define the necessary changes to achieve it. Our tests shown that loading problems increases as the instance size increase, but feasible loading can often be achieved by only minor changes on the routing solution and therefore with limited additional costs. Additionally, making a consistent delivery plan, instead of individual plans for each day, ensures that the products arrive around the same time to the stores and enables the reduction of the total cost of the distribution, considering routing and time-window penalty costs. A consistent distribution planning helps to smooth the in-store operations.

Acknowledgments

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What future for health expenditures? A time series analysis

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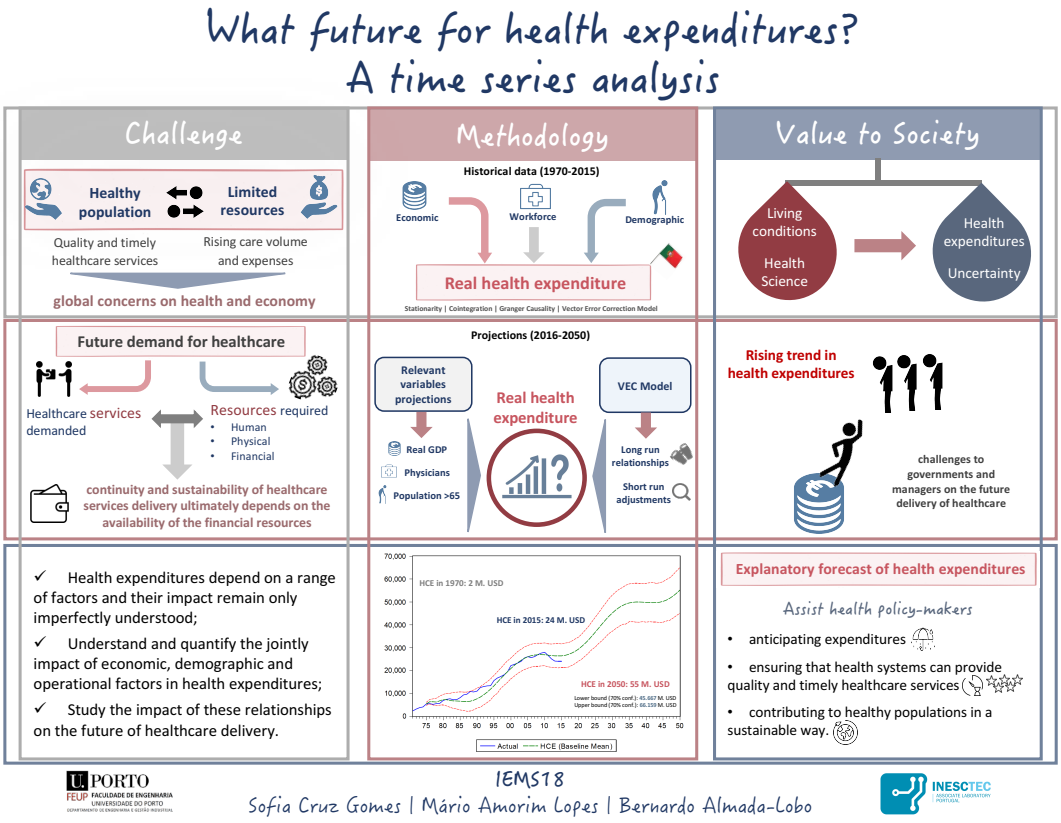

1 The Challenge

Ideally, a health system provides quality and timely care services, contributing to a healthy population. However, as most health systems have been facing rising care volumes and expenditures, and resources are limited, those aforementioned goals are at risk.

The work hereby presented is part of an approach which aims to build a comprehensive and thorough study on planning the demand for healthcare services and resources. Overall, the problem can be summarized as the need to ensure that the appropriate healthcare services will be provided to the patients who seek for them. Ensuring that future demand will be met depends on planning both the healthcare services that will be demanded and the resources - human, physical and financial - required to deliver them. Ultimately, healthcare delivery is dependent on the availability of the financial resources needed to provide all the necessary inputs to produce the demanded services.

Nowadays, health expenditures planning is critical for ensuring the continuity and sustainability of healthcare services delivery. It is also genneraly accepted that expenditures on health depend on a range of

factors, whose relevance should be assessed and integrated in forecast models. Despite the undeniable interest of the topic, the factors driving health expenditures remain only imperfectly understood and empirical explanatory forecasts applying multivariable approaches are few. In fact, although the relation between health expenditures and economic activity has been widely studied, not enough attention has been given to comprehensive studies on understanding and quantifying the jointly impact of economic, demographic and operational factors in health expenditures and on the impact of these relationships on the future of healthcare delivery.

Through an empirical analysis for Portugal, we aim to develop a time series model to explain and forecast the health expenditure, accounting for the evolution of several health expenditures drivers. In this context, the existence of a long-term causality relation between health expenditures, economic growth, healthcare workforce and demographic variables is investigated through the use of different time series techniques and models, and future health expenditures are projected based on the achieved results and on projections of the relevant variables.

2 The Methodology

In order to tackle this problem, we started by reviewing the key literature on health expenditures for a deeper understanding of the scope, advantages and limitations of the assorted models and approaches to health expenditures forecasts. Identifying the main research gaps enabled us to define the direction of our research and frame our contribution.

Using data from the Organisation for Economic Co-operation and Development (OECD) and from the Statistics Portugal (Instituto Nacional de Estatística, INE), we constructed a dataset with historical information of the most relevant drivers of health expenditures for the period 1970-2014. For the demand-side we selected the Gross Domestic Product (GDP) to represent the socio-economic conditions and the share of elderly population as a proxy for the demographic changes. For the supply-side, the number of physicians was chosen for three main reasons: first, because healthcare is a labour-intensive industry; second, because the number of physicians has been the indicator selected to capture the supply-induced demand (SID) effect, as it is known that supply and demand for healthcare are not independent from each other and that asymmetric information exists between physicians and patients; and third, because from a higher access of healthcare usually comes a higher utilisation, specially in the presence of unmet needs. Projections for these variables from 2015 to 2050 were also collected and included in our dataset.

We started by studying the time series stationarity, performing a set of unit root tests. After concluding for the non-stationarity of the series, we performed a Granger Causality test to understand the relation between healthcare expenditure and its drivers, and we carried out a cointegration analysis to detect a long-run relationship between healthcare expenditures and a set of determinants. The Johansen cointegration test performed showed that the time series are cointegrated and pointed the model to be used when time-series are non-stationary and cointegrated: a Vector Error Correction (VEC). A VEC model considering the relevant drivers of health expenditure and a time trend to serve as proxy for the technology was then estimated, allowing the understanding of both the long-run relationship and the short-run dynamics between the variables. Finally, we checked the forecast capability of our model using historical data, and we used the variables projections to forecast health expenditures until 2050.

Our approach differs from previous studies by conjoining three main aspects. First, we use time series techniques, such as unit roots and cointegration methodologies, to detect non-stationarity and long-run relationships between the health expenditures and other variables of interest. A multi-equation econometric time-series model is used to explore and describe both the long-run relationships and the short-run dynamics between the variables, and health expenditures forecasts are made using the estimated model. Second, most of these time-series studies only examine the relation between health expenditures and the GDP. Only a small share of studies include cointegration analysis across other variables of interest. In our study, we consider a multivariable approach considering the most relevant drivers of health expenditures, both on the demand- and on the supply-side. Finally, we perform a macro analysis at the single-country level to provide an aggregate view and identify national specificities and trends. Although it has been pointed that healthcare expenditures are not homogeneous across countries, country-specific studies are uncommon. To the best of our knowledge, no such application of a similar approach to health

expenditures exists.

3 The value to Society

The improved living conditions and the advances in medical science that occurred in the past decades led to significant improvements in health and longevity. However, together with this achievement came a number of changes that are raising global health and economic concerns. Healthcare systems around the world are now facing rising health expenditures and uncertainty about whether there will be enough resources to deliver the demanded services, which has been calling the attention of health researchers, managers and policy-makers.

Our approach yields into a simple yet effective tool to understand and forecast health expenditures at the country level. By accounting for the most relevant drivers of health expenditures, both on the demand- and on the supply-side, this approach may result in more solid and realistic forecasts. Furthermore, providing a better understanding of both the long-run relationship between health expenditures and other macro-level indicators, and of the adjustments when deviations from the long-run equilibrium occur is of major worth, as it may help to anticipate health expenditures, allowing for a more accurate planning.

Hence, by developing an explanatory forecast for health expenditures at the country-level we hope not only to make a scientific contribution to the field, but also to provide a decision support tool to assist health policy-makers anticipating expenditures and ensuring that health systems can continue to provide quality and timely healthcare services and to contribute to healthy populations in a sustainable way.

Finally, and besides the overall value of the topic, the problem is real and of extreme importance for countries such as Portugal, where health expenditures as a percentage of the GDP almost quadruplicate in 40 years and the abovementioned concerns on sustainability are prominent.

Integrating Supplier Selection to Foster Strategic Supply Chain Management

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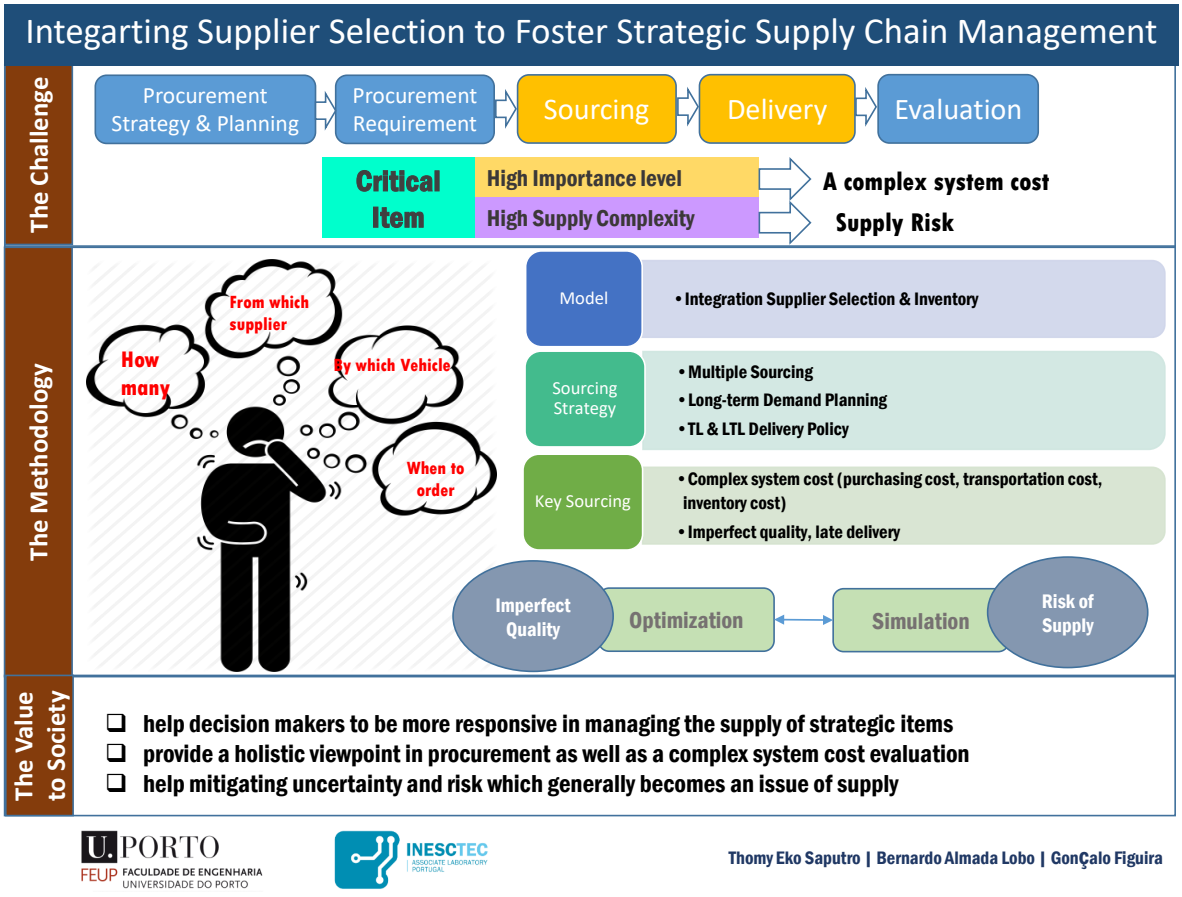

1 The Challenge

Procurement has been recognized as a strategic supply chain function. Supplier selection is one of the most influential activities in purchasing which influences the performance of the whole supply chain. It is also crucial for ensuring the continuity of supply, the time-to-market, and the on-time delivery. Selecting the most appropriate supplier is a complex decision-making process (as can be seen in Figure 1).

According to the importance of purchasing and complexity of supply (see Figure 2), there are four types of items which are classified into critical, leverage, bottleneck, and non-critical. The importance of purchasing can be assessed based on product quality impact, business growth, and profit (defined in terms of the volume purchased & percentage of total purchase). Meanwhile, Supply complexity includes market competitiveness, make-or-buy opportunities, storage risks and substitution possibilities. Each type of item requires different key sourcing requirements and strategy. A critical item such as a raw material (i.e. wood fiber in the paper production) is the most important one because it has a high risk

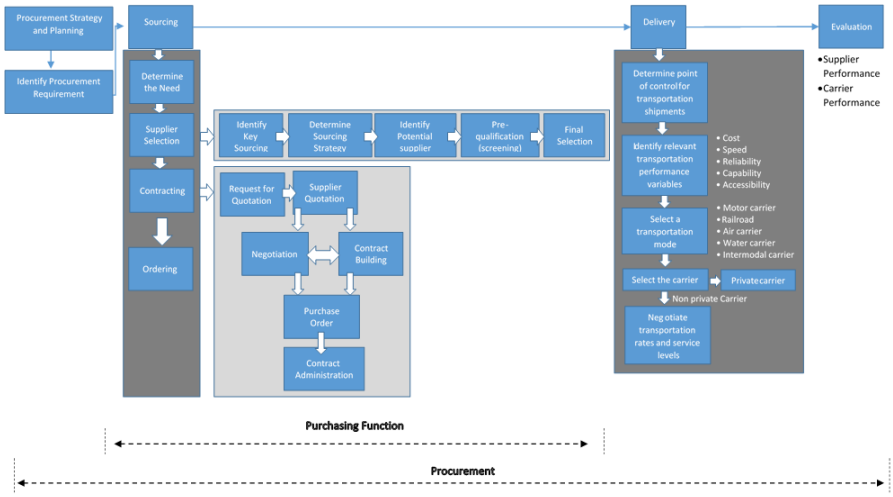

Figure 1: Procurement process in general practice

and impact on production systems. Supplier selection of critical items is the concern of this research since it plays an important role both in procurement and production systems.

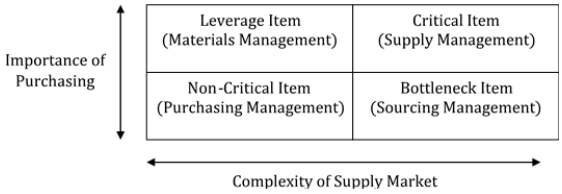

Figure 2: Purchasing classification

Several studies on supplier selection have been proposed particularly for an integration of supplier selection with other functions within procurement such as order allocation, inventory, and expedition (transportation), also with other cross-functional decisions in the supply chain such as production planning and reverse logistics. However, there is still a need for further research on the integration of supplier selection and inventory management, production and distribution planning. In this research, we focus on the complex system cost including purchasing, inventory, and transportation by considering different transportation policies such as truck-load (TL) and less then-truck-load. The complex system cost can be advantageous to compensate transportation cost without compromising delivery performance. In addition, a mitigation of uncertainty and risk of supply in terms of quality and delivery are not well incorporated by the past studies. Since particular parameters related to the suppliers performance (i.e. capacity, quality, delivery) and buyer (i.e. demand) are uncertain, there is a negative impact on the supply and the total cost. By recognizing the presence of the impacts, there is a need of strengthening the supply chain strategically through an advanced supplier selection. In order to represent the problem more realistically, in this research, we provide a model extension by incorporating disruption events which cause a problem on delivery and supply capacity. The degree of occurrence and severity are defined in the disruption event. In fact, none of the studies have incorporated these problem characteristics holistically in procurement.

2 The Methodology

This study intends to extend the problem characteristics and improve the solution method of past studies on supplier selection (see Figure 3). We attempt to tackle the integration of supplier selection and inventory under uncertainty and risk of supply. In particular, we focus on a specific item and sourcing strategy that addresses critical items and multiple sourcing respectively. The strategic decisions refer to supplier selection, while the tactical decisions in procurement include order allocation, reorder point, and vehicle selection that are determined simultaneously according to a complex system cost.

In order to improve the solution method, simulation-optimization is employed. A metaheuristic is applied to solve supplier selection and vehicle selection. The objective function of the integrated problem is constructed to minimize a complex system cost including inventory, purchasing, and transportation cost as well as imperfect quality. Furthermore, a discrete-event simulation model is built to mitigate the risk of supply and to refine the solution obtained from metaheuristics. Disruptions need to be simulated according to the level of occurrence and severity in order to run the model more realistically. The disruption is the driving factor triggering lead time variability, which is critical since it can increase the possibility of having stock outs. Nevertheless, lead time variability due to disruption cannot be easily addressed with mathematical programming. Therefore, simulation is used to model such disruptions. Finally, we refine the solution (order quantity, reorder point) by using a better-estimated lead time which is obtained from simulation.

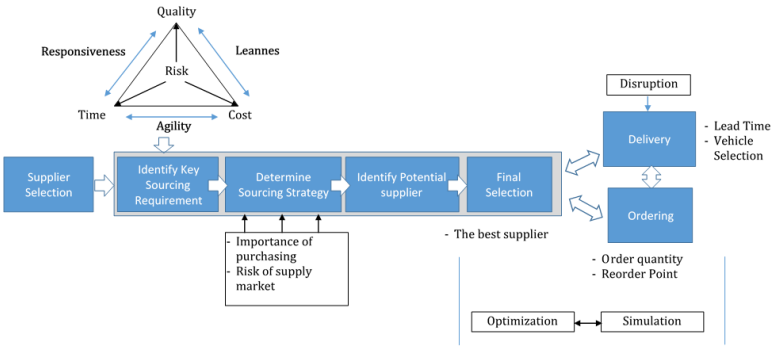

Figure 3: Conceptual model for supplier selection process in strategic supply chain management

3 The value to Society

This study intends to draw insights for strengthening traditional supplier selection with a strategic role within the supply chain. Regarding managerial implication, the proposed supplier selection can help decision makers to be more responsive in managing the supply of critical items. The integration of supplier selection, inventory management, and transportation provide a holistic viewpoint in procurement. In addition, the approach used to solve the problem can help mitigating uncertainty and risk which generally become an issue of supply. Disruption of supply cannot be avoided but at least its occurrence and severity can be mitigated to build a competitive supply chain which ultimately helps us to meet the customers demand with a better fulfillment at a lower overall cost.

Product line design: a mathematical model with operational considerations

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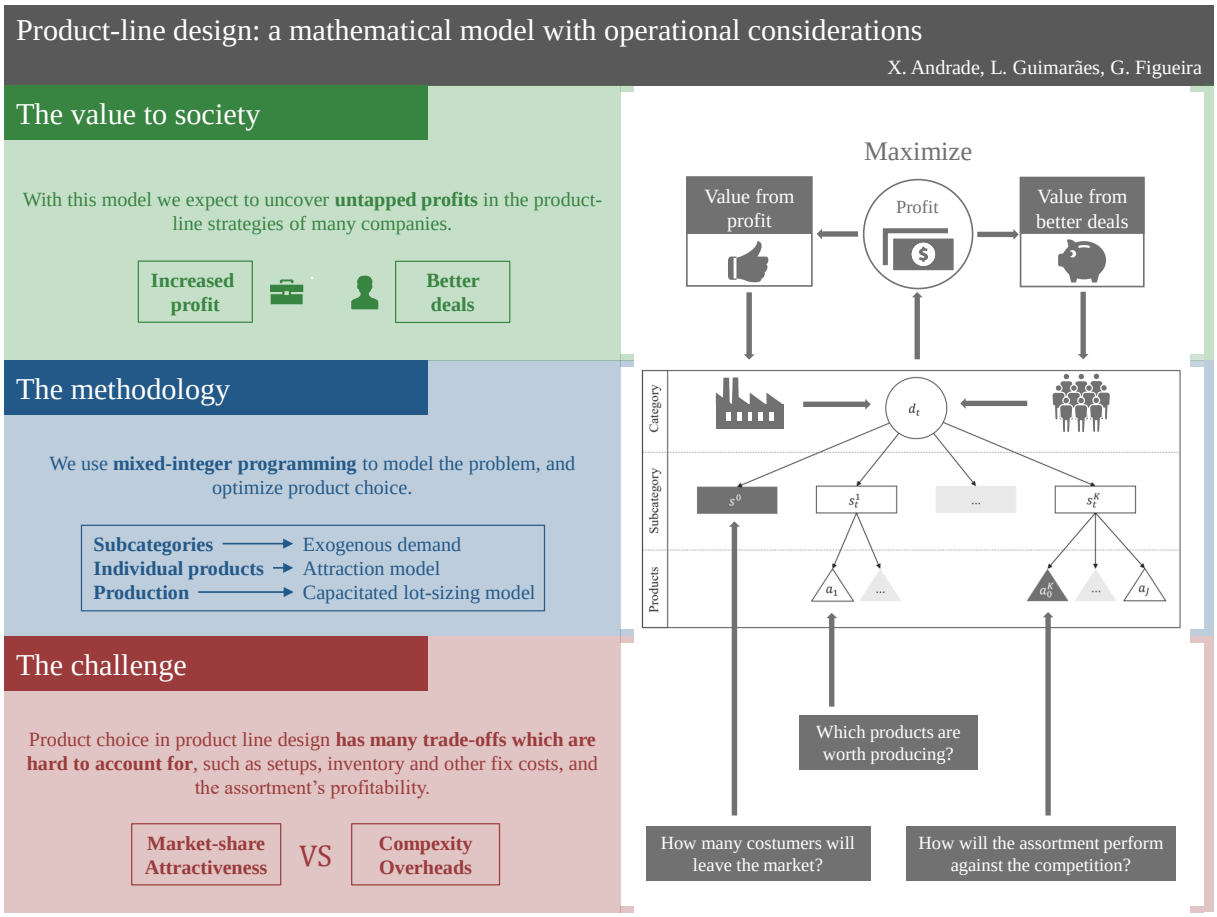

1 The Challenge

When planning an extension, or a reduction in product line breadth, several dimensions should be considered. There is a wide belief that the added complexity of operations from adding a new product variant results in additional overhead costs, greater material handling, more process variability, and increased time spent in setups, which takes a toll on capacity. With more variety, although better fits between the production and the product desired by the consumers are enabled, loss of focus is expected. Adding to this, it is sensible to note that these costs can be industry, and even manufacturer specific, as not every business, or plant design, is equally prone to economies of scope, and to accommodate variety. Commonalities between the different varieties, in both the process and the materials used, and late differentiation are design traits that demonstrate aptitude for mass customization. Additionally, short invariable setups, precise and exact forecasting, and excessive capacity are operational traits that make variety more easily accommodated. On the other hand, a strong conjecture against variety states that, although product variety can increase the attractiveness of a category, it is not expected that the total demand for that category increases. Hence, product proliferation is a strategy for market-share appropriation and entry

deterrence. More so, systematic competition for market-share using product-line extensions can lead the players to the uncomfortable position of having otherwise unnecessary complexity costs, which makes this kind of competition analogous to the prisoner's dilemma.

Given the difficulty of the managerial trade-offs involved in product-line design, the significance of the impacts, and the lack of accountability resulting from the product proliferation strategies, we find that there is a real-world need for quantitative models to support these decisions. Furthermore, the academic literature in this particular topic is lacking development, and applicability. When product-line design is tackled in marketing research, the cost structure is oversimplified, and sometimes even ignored. When operations research tackles this problem, demand is assumed as uncontrollable, and unresponsive to the assortment.

2 The Methodology

We develop a mathematical model for product-line decisions which accounts for the various specificities of this decision, while being kept simple enough to be optimally solved for real-world sized instances. For this means, we recur to mixed-integer linear programming, and generate instances in order to assess the model's performance. We ground the decision of producing a product, in a given planning horizon, on the economic trade-offs of the manufacturer, based on the optimal production plan that can be modeled as a capacitated lot-sizing problem with setup times, making setup and inventory costs accountable for. Additionally, as Figure 1 describes, demand is dependent on the manufacturer's product range. Inside each subcategory, we use an attraction model (i.e. a product's market share is calculated by its attractiveness, relative to the attractiveness of the whole assortment) to model demand. For the different subcategories, we nest the attraction models into an exogenous demand model, which makes the model unique in the literature. In this exogenous demand model, the portions of the total demand captured by each subcategory are defined, as well as the recapture ability of between every subcategory pair.

By nesting an attraction model within an exogenous one, we manage to circumvent the independence of irrelevant alternatives, and by integrating this structure into a multiple-product lot-sizing model we include the specificities of manufacturing into the problem. The model allows trade-offs such as that of revenue with complexity costs, of market-share with product profitability to be handled, in a complex demand setting. Furthermore, in this model, the performance of a strategic decision, i.e. producing a product, is assessed by the profit of the optimal lot-size, thus by how efficiently the operational level performs. As for future work, the model would benefit from incorporating the added uncertainty of having a broad product line, as the product-level forecasting would be harder. This can be implemented either by enforcing a safety stock rule or with the use of stochastic programming, by modeling the uncertainty in the demand parameters.

3 The value to Society

Companies are facing an ever increasing pressure to improve their operational efficiency. When discussing the performance of a company both revenue and costs must be accounted simultaneously, though it is frequent that their sources are managed separately. While the pressure to generate revenue usually falls on the sales and marketing officers, the responsibility to keep costs low, hence guaranteeing a margin, is that of the production managers. On one hand, by conceiving, pricing, promoting, and distributing a product marketeers aim to foster utility maximizing trades with consumers. On the other hand, production managers facilitate the resources needed to manufacture these products, and administer them so this is done at minimum cost. These perspectives are usually conflicting, yet the need for interfaces between them, from a managerial standpoint, is recognized by both.

While conjoint marketing-operations research includes other decision problems such as capacity planning, production scheduling, distribution and delivery, quality, cost control, product introduction, and supporting services, the scope of this work is limited to product-line breadth. In this topic, with the complex demand structure, we expect to bring the possibility modeling new market structures, thus increasing

the applicability of optimization techniques to this kind of issues. Moreover, with the integration of the demand model into the capacitated lot-sizing problem with setup times, we expect to uncover untapped profits in many of the companies product line strategies.

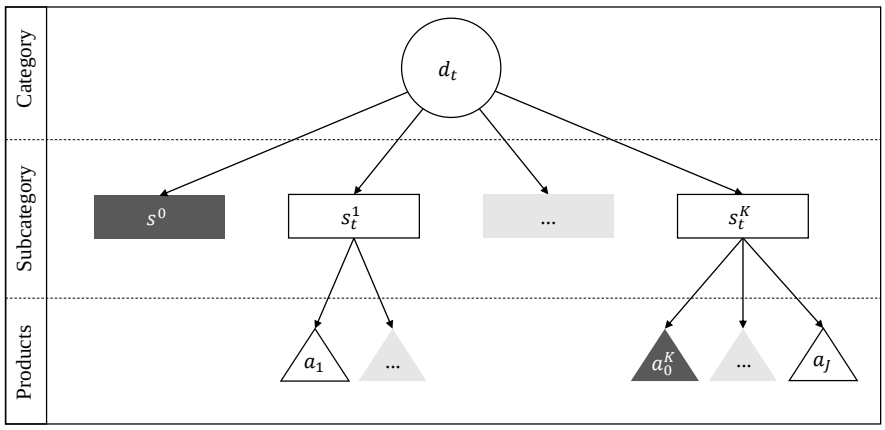

Figure 1: The demand for a product category is distributed by its subcategories, this is defined exogenously. The distribution inside the subcategories is defined as the fraction of the attractiveness of the product, over that of the subcategory.

End to End Abstracts

HS.Register - an audit-trail tool to respond to the General Data Protection Regulation

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The new General Data Protection Regulation (GDPR) mandates health care institutions and their software providers to properly document all personal data treatments and provide clear evidence that their systems are behaving as mandated by the GDPR. All applications involved on personal data treatments should therefore produce meaningful event logs that can later be used for the effective auditing of complex processes. Moreover the large number of software applications, medical devices and providers inside hospitals turns auditing for GDPR compliancy into a very complex and difficult process. HS.Register, a system developed to collect and securely manage at scale audit logs and data produced by a large number of systems that are involved in the treatment of personal data inside a Hospital. It creates a single audit log repository, by collecting and aggregating all kinds meaningful event logs and data (e.g. ActiveDirectory, syslog, log4j, web server logs, REST, SOAP and HL7 messages). It also includes specially build dashboards for easy auditing and monitoring of complex processes, crossing different systems in an integrated way, as well as providing tools for helping on the auditing and on the diagnostics of difficult problems, using a simple web application. HS.Register is currently installed at five large Portuguese Hospitals and is composed by the following open-source components: HAproxy, RabbitMQ, Elasticsearch, Logstash and Kibana. HS.Register currently collects and analyzes an average of 93 million events per week and it is being used to document and audit HL7 communications at five large Portuguese Hospitals. It is used not only for GDPR compliancy but also for problem finding on the infrastructure and feeding monitoring tools. Auditing tools like HS.Register are likely to become mandatory in the near future to allow for traceability and detailed auditing for GDPR compliancy.

Anda Project: Simplification and Improvement of the Andante system

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The current Andante intermodal system has been expanding its temporal and spatial coverage and having a growing acceptance by customers and transport operators from the Metropolitan Area of Porto. Despite such achievements, the use of public transport services has not yet reached the desired intensity given the excessive complexity of the Andante ticketing system and tariff rules. Transportes Intermodais do Porto (TIP), in partnership with the Faculty of Engineering of the University of Porto (FEUP), is developing a project, called ANDA, which main aim is to simplify the use of the Andante system and the customers' vision of its use.

The project consists in designing and developing a public transport payment solution based on customersâ mobile phones, and of a network of beacons and NFC readers installed in vehicles and stations. When travelling the customer only needs to check-in at the boarding stop/station and the system will locate him during the trip (check-in / be-out system). The customer will then receive the invoice to pay for the trips he has performed during a certain period of time (usually a calendar month). The price to pay for the trips is calculated by optimizing the tariffs of the Andante intermodal system, ensuring the payment of the minimum amount possible. The use of this ticketing solution does not require any prior knowledge about tariffs and zones of the Andante network and therefore expects to have new clients that until now did not use public transport in Porto due to the excessive complexity of using Andante.

The role of advanced nurse practitioners in achieving health gains and quality of care

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Provider shortages and geographical imbalances may result in unmet care needs. The problem is aggravated further when we consider population ageing and the expansion of chronic illnesses and comorbidities, which suggest a higher demand for health care services in the future. Widening clinical roles for nurses through task-shifting and expansion of scope-of-practice may harness their contribution to mitigating these needs, but also to more effective health care delivery and improved quality of care. However, such organizational change entails great challenges, such as devising nurse residency programs and promoting policies that push the change. In this work we make the case for expanding the clinical roles of nurses in Portugal. To do so, we analyse a wide array of empirical evidence regarding the impact of advanced nursing practitioners (ANPs) in primary care and hospital settings. Second, we conduct a cross-country analysis to understand the impact ANPs have in different health systems, highlighting the experience of countries that feature a health system similar to Portugal. Third, we forecast the impact of implementing nurse residency programs on the nursing workforce and provide estimates of the cost to the public budget. Finally, we provide policy insights and recommendations of how such organizational may be enabled in the Portuguese NHS.