



IEMS'17

8th Industrial Engineering and Management Symposium

The Impact of DEGI Research on Society

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Abstracts Booklet of IEMS'17

8th Industrial Engineering and Management Symposium:
The Impact of DEGI Research on Society

Editor: José Sarsfield Cabral

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Organizing Committee:

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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!

The “Industrial Engineering and Management Symposium” (IEMS) is an annual event that marks the collective life of the Department of Industrial Engineering and Management (DEGI) of the Faculty of Engineering of the University of Porto. It is a celebration of the vitality of DEGI’s research, in close association with companies from both the industrial and service sectors and other organisations, as well as of the quality of the work of the PhD students enrolled in the Industrial Engineering and Management Doctoral program, or in any other way conducting their work under supervision of the DEGI’s teaching staff. This event is so deeply intertwined with the life and history of the DEGI that this history is worthy of account on occasion of the 8th edition of IEMS.

The roots of DEGI go back to 1975, namely to the creation of the “Section of Economy, Organisation and Management” within the Department of Mechanical Engineering. Following this decision, Rui Guimarães was “sent” to Lancaster University to complete a MSc. and a PhD. in Operations Research. He returned in 1980, and in 1982 the aforementioned Section gives rise to the Industrial Management Unit (GEIN). It is worth recalling the driving factors underlying the creation of the GEIN: “[...] the need to improve the quality of teaching in the field of management, to develop links with the industrial world and to identify and carry out applied research projects”. These very same driving factors still lay behind this symposium every year. In the origin of GEIN, three names stand out: Rui Guimarães, Bernardo Calafate and Carlos Moreira da Silva.

Meanwhile, in the late eighties other young faculties returned to the Department of Electrical and Computers Engineering upon conclusion of their PhDs abroad, either in Operations Research, or in some other discipline with a strong emphasis on the methods and techniques of Operations Research. A small core of people working on Industrial Engineering and Management grew in this department, in close cooperation with GEIN, on account of the good personal and professional relationships among the members of the two groups.

In the academic year of 1983-1984 GEIN launches the Production and Management branch within the 5-year degree in Mechanical Engineering, and in 1990 an autonomous 5-year program in Industrial Engineering and Management is also created. Later, this program gives rise to the 5-year Master in Industrial Engineering and Management. With an initial numerus clausus of 25 students, this program was able to, from its very first edition, attract the brightest candidates, by means of a rather demanding admission process. In the present academic year, with already a numerus clausus of 75, the Master in Industrial Engineering and Management ranked 3rd in the country, the lowest admission mark being 18.48 over 20. The current Director of this master program, Ana Camanho, is one of the graduates of the program’s very first edition. In the academic year of 2007-2008, by initiative of João Falcão e Cunha, the Doctoral Program in Industrial Engineering and Management is launched with the original and perennial goal: to train people in the field of Industrial Engineering and Management at the highest level, in close connection with the industrial world, and conducting applied research which addresses real-world needs. This program is currently directed by Maria Antónia Carravilla.

Upon approval by the governing bodies of the Faculty of Engineering, the autonomization of the Industrial Engineering and Management area takes a step forward with the creation of the DEGI, by bringing together GEIN and the (smaller) counterpart group from the Electrical and Computers Engineering department. José António Sarsfield Cabral fathered the idea and carried it through to completion. First head of Department, he still serves the DEGI in this position.

The new department started its activity formally in January 2008 and one year later Bernardo Almada-Lobo proposed the creation of two events: the IEMS and the DEGI Club. The DEGI Club takes place every other week, and is a meeting of PhD students and teaching staff where PhD students present their work to a broader audience, teaching staff talk about ongoing research and current trends in their expertise fields, invitees from companies propose challenges to the academic community, and tutorials on

general interest topics are given. IEMS, a yearly event, has similar purposes although aiming to discuss work that reached a higher level of completion. Over the years IEMS grew from the initial idea until it became what it is today: the opening of DEGI and its research activity to the outside world, business companies and academic institutions alike. The fact that this event is run exclusively by a team of PhD students provides ample evidence of its maturity.

With 31 permanent teaching staff members, and 9 full-time-equivalent part-time teaching staff, today's DEGI is in charge of around 420 full-time-equivalent students enrolled in 60 courses. It runs not only the above mentioned Master and Doctoral Programs in Industrial Engineering and Management, but also the Master in Engineering and Service Management, directed by Lia Patrício, and the Master in Innovation and Technological Entrepreneurship, a joint program with the Faculty of Economics directed by João José Pinto Ferreira. DEGI also maintains strong connections with the Doctoral Program in Transport Systems, a joint program with the Universities of Coimbra and Lisboa directed by Jorge Pinho de Sousa.

The majority of DEGI members conduct their research activity within INESC TEC, the Institute for Systems and Computer Engineering, Technology and Science. Being one of the largest research institutes in Portugal, with more than 650 researchers spread across 6 different sites in Porto, Braga and Vila Real, INESC TEC is organised in research centres. DEGI research activity is strongly related to the Centre for Enterprise Systems Engineering, the Centre for Innovation, Technology and Entrepreneurship and the Centre for Industrial Engineering and Management, which are led by DEGI faculties.

It is the result of this rich Industrial Engineering and Management eco-system, centred on the Department of Industrial Engineering and Management of the Faculty of Engineering of the University of Porto, that welcomes you today to IEMS'17 – the 8th Industrial Engineering and Management Symposium. To all of you attending this symposium and to all those who made it a reality, thank you very much.

The Director of DEGI
José António Sarsfield Cabral

(Text written by José Fernando Oliveira, sub-director of DEGI,
based on José António Sarsfield Cabral's presentation at the DEGI Club on October, the 14th 2016)

Information for Participants

Symposium Venue

The symposium will take place at Ateneu Comercial do Porto, an emblematic space of the city of Porto. Ateneu Comercial do Porto was founded in 1869 and has been based at Rua Passos Manuel since 1885. Originally a recreational society, it stood out for almost 150 years in the promotion of civic and cultural movements in the arts and sciences, as well as ludic activities such as dances, soirees and tertulias.

The venue information is detailed below:

- Address: Rua Passos Manuel, no. 44, 4000 – 381 Porto;
- Tel.: (+351) 223 395 410
- Email: geral@ateneucomercialporto.pt



Figure 1: Main Hall of the *Salão Nobre*, Ateneu Comercial do Porto.



Figure 2: *Salão Nobre*, Ateneu Comercial do Porto.

The nearest metro stop is “Bolhão” (5 minutes walking). There will be no private parking.

When you arrive at the venue, please perform the check-in at the Main Hall of the *Salão Nobre*, see Figure 1. Coffee breaks will be served at the main hall as well. All oral communications of IEMS'17 will occur at the *Salão Nobre*, see Figure 2.

Lunch

The lunch will be served at the ACISJF - *Associação Católica Internacional ao Serviço da Juventude Feminina*. Please see the directions of the pedestrian path in the map provided at Figure 3. Lunch is a courtesy of DEGI–FEUP.

Internet

There is Wi-Fi access in the *Salão Nobre* of Ateneu Comercial do Porto. The Wi-Fi password will be provided along with the check-in documentation.



Figure 3: Pedestrian path between Ateneu Comercial do Porto and the restaurant of ACISJF.

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'17 website: <http://www.fe.up.pt/~degi/iems17>. During the breaks, the elevator pitches will also be displayed near the auditorium. A bulletin containing thumbnails of the elevator pitches will be distributed to all participants. Each participant has three votes.

Program Schedule

Thursday, January 5th

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

Opening Session: 8:55 – 9:00 (Salão Nobre)

Chair: Jorge Grenha Teixeira

PhD Projects: 09:00 – 10:20 (Salão Nobre)

A.1 – Solving a Large Production-Routing Problem in a Vertical Meat Store Chain

Fábio Neves-Moreira, Luís Guimarães, Bernardo Almada-Lobo, Jean-François Cordeau, Raf Jans

A.2 – A Service Perspective to Customer Engagement with Smart Grids: Co-Creating Value with Smart Energy Services

Luísa Gonçalves, Lia Patrício

A.3 – The impact of servitization on the performance of manufacturing firms over time: An empirical investigation in the elevator industry

Miguel Leichsenring Franco, Bernardo Almada-Lobo, Rui Soucasaux Sousa

A.4 – A Benders Decomposition Approach to the Berth Allocation Problem

Flávia Barbosa, José Fernando Oliveira, Maria Antónia Carravilla

Coffee-Break: 10:20 – 10:40 (Hall)

Round Table: 10:40 – 11:40 (Salão Nobre)

Urban Mobility – Trends, Perspectives and Research Opportunities

Coordination:

Jorge Pinho de Sousa (FEUP)

Guest Speakers:

Cristina Pimentel (Câmara Municipal do Porto)

Jorge Moreno Delgado (Metro do Porto / STCP)

Paulo Pinho (FEUP and CITTA)

Edgar Jimenez (University and Municipality of Ibagué, Colombia)

Elevator Pitches: 11:40 – 12:20 (Salão Nobre)

Marta Campos Ferreira, Jihoon Shin, Débora de São José, Abílio P. Pacheco, Sara Martins and Nuno Falcão e Cunha

Lunch: 12:20 – 14:20 (*Restaurant of the ACISJF - Associação Católica Internacional ao Serviço da Juventude Feminina*)

Chair: Elsa Silva

End to End: 14:20 – 14:50 (*Salão Nobre*)

B.1 – Service Assisted Living (SAL): Designing new services for the blood value chain and melanoma
From FEUP: Lia Patrício and Jorge Grenha Teixeira.
From GLINTT: Carlos Beco.

Specialized Session: 14:50 – 15:20 (*Salão Nobre*)

B.2 – Moving from Relational to NoSQL: Using MapReduce to process big data sets
Miguel Oliveira

Elevator Pitches: 15:20 – 15:50 (*Salão Nobre*)

Maria João Pires, Eduardo Curcio, Ariane Rodrigues Pereira, Dario Messina, Sofia Cruz-Gomes, Xavier Andrade and Parisa Sadeghi.

Coffee-Break: 15:50 – 16:20 (*Hall*)

PhD Projects: 16:20 – 17:40 (*Salão Nobre*)

C.1 – An Ontology of Urban Mobility Events for Supporting Visualization Tools
Thiago Sobral, Teresa Galvão Dias, José Luís Borges

C.2 – Integrating pricing and capacity decisions in car rental companies
Beatriz Brito Oliveira, Maria Antónia Carravilla, José Fernando Oliveira

C.3 – Height estimation for the two-dimensional strip packing problem
Álvaro Neuenfeldt Júnior, Elsa Silva, José Fernando Oliveira, A. Miguel Gomes

C.4 – Physician emigration: should they stay or should they go? A policy analysis
Mário Amorim Lopes, Álvaro S. Almeida, Bernardo Almada-Lobo

Award for the best elevator pitch and Closing Session: 17:50 (*Salão Nobre*)

Abstracts

Fire environment and suppression (un)balance

— characteristics and drivers of extreme wildfires in Portugal —

Abílio P. Pacheco*[†], Paulo M. Fernandes[‡], João Claro*[†], Rui Almeida[§]

*Faculdade de Engenharia da Universidade do Porto, [†]INESC TEC, [‡]CITAB, Universidade de Trás-os-Montes e Alto Douro, UTAD, [§]Instituto da Conservação da Natureza e das Florestas



fire
environment and suppression
(un)balance
— characteristics and drivers of extreme wildfires in Portugal

Abílio Pereira Pacheco
Paulo M. Fernandes
João Claro
Rui Almeida

METHODOLOGY
regression study
dataset of extremely large fires (>=2500 ha) built more than a hundred fire reports analyzed Portugal, 2003-2013
regression tree analysis (CART)
GLM (LOGIT) modelling

CHALLENGE
worldwide surge in mega-fires
climate change driven
severe environmental and socio-economic impacts
disproportionately high percentage of fire management budgets

uncertain and highly unpredictable factors

- weather forecasts
- performance of suppression resources
- fire behavior, spread and effects

across multiple levels and scales
at both policy and operational levels

VALUE TO SOCIETY

- inadequate incident management
- opportunistic nature of large-fire containment are highlighted by the results

management and operational improvements leading to faster containment are recommended rather than higher fire-suppression resourcing

identification/exploration of containment opportunities
– preferable to suppression resources accumulation

containment opportunities can be fostered through landscape-scale fuel treatment projects and by increasing community fire awareness

↑ self-protection level ⇒ ↓ fire-suppression resources deviation to urban interface

especially relevant in the current context where a discussion is underway around prevention/suppression budgets

1 The Challenge

Global change is driving a worldwide surge in mega-fires, which are notorious for severe environmental and socio-economic impacts, and absorb a disproportionately high percentage of fire management budgets. Uncertain and highly unpredictable factors, such as weather forecasts, performance of suppression resources, and fire behavior, spread and effects are the basis of fire management decisions, across multiple levels and scales, at both policy and operational levels. Even if large forest fires constitute a small percentage of the total number of fires, they are responsible for a disproportionately high fraction of area burned and the consequent effects: depending on the country, fires larger than 500 ha represented 0.3 – 2.1 % of the total number of ignitions, but accounted for 16 – 48 % of total area burned.

This study addresses extremely large fires (ELF, ≥ 2500 ha) in Portugal (2003 – 2013) being extendable to the study of other issues in disaster management. We analyzed the effect of fire-suppression force variation on ELF duration, size and growth rate, versus the effect of the concomitant fire environment (namely fuel and weather) conditions. ELF occurred in highly flammable landscapes and typically were impelled by extreme fire weather conditions.

2 The Methodology

For this regression study we built a dataset of extremely large fires (ELF, ≥ 2500 ha) in Portugal (2003 – 2013) to assess the effect of fire-suppression force variation versus the effect of the concurrent fire environment conditions (fuel hazard and weather) on ELF duration, size and growth rate.

We used two methods to obtain the amount of time (T) elapsed between ignition and the moment beyond which the fire is contained and ceases to increase in area. The first consisted of estimating T (Figure 1, next page), and the second in examining the records supplied by ANPC (Civil Protection National Authority) to find the date-time of the change of state to "fire under control" (Figure 1, top). To estimate T, we used a database supplied by ANPC containing the records of the suppression resources used in the fires occurring between 2006 and 2013; for 2003-2005, when this type of data started to be collected, we used a database compiled from scattered data, locally recorded by the no longer existing SNBPC (National Firefighters and Civil Protection Service); detailed information lacked for earlier fires.

Containment time and estimates of fire growth rate, power of the fire and total energy release varied in the respective ranges of 4-112 h, 27-1244 ha h⁻¹, 3-122 GW, and 0.6-10.2 TJ. The allocation of suppression resources (normalized per unit of burned area or perimeter length) was disparate among fires, suggesting inadequate incident management.

In order to evaluate the influence of fire environment and fire suppression factors in the time to containment T, we use GLM (LOGIT) and regression tree analysis (CART). GLM modelling (unpublished) indicated fire environment to fire suppression ratios of influence of 11:7 for fire size, and 9:10 or 13:10 for fire growth rate, explaining only 23% to 34% of the variability.

Regression tree analysis indicated that higher fire suppression resourcing and higher presence of j9-year-old fuels reduces the ELF size and growth rate (i.e., has a positive effect regarding the limitation of fire impacts on the environment), whereas more severe fire weather is associated to higher values of ELF size and growth rate (i.e., worse impact on the environment) as well as higher time to containment to ELF size. Fire environment to fire suppression ratios of influence were 3:1 for fire size and 1:1 for fire growth rate, respectively, explaining 76 and 60% of the existing variability and highlight inefficiencies in the suppression efforts.

3 The value to Society

The results address the nature of large-fire containment highlighting the opportunistic nature of large-fire containment and suggest inadequate incident management. Managerial and operational improvements to further advance the understanding of ELFs are recommended. Data limitations inherent to the methods used are discussed and improvements to further advance the understanding of extreme fires are suggested.

To minimize the area burned by ELF, management and operational improvements leading to faster containment are recommended, rather than higher fire-suppression resourcing; more effective identification and exploration of containment opportunities are preferable to the accumulation of suppression resources. Containment opportunities can be fostered through landscape-scale fuel treatment projects and by increasing community fire awareness to increase the level of self-protection, hence lowering fire-suppression resources deviation to the wildland-urban interface.

Our study is especially relevant in the current context of fire management in Portugal, where a discussion around the budgets for prevention and suppression is underway at a policy level.

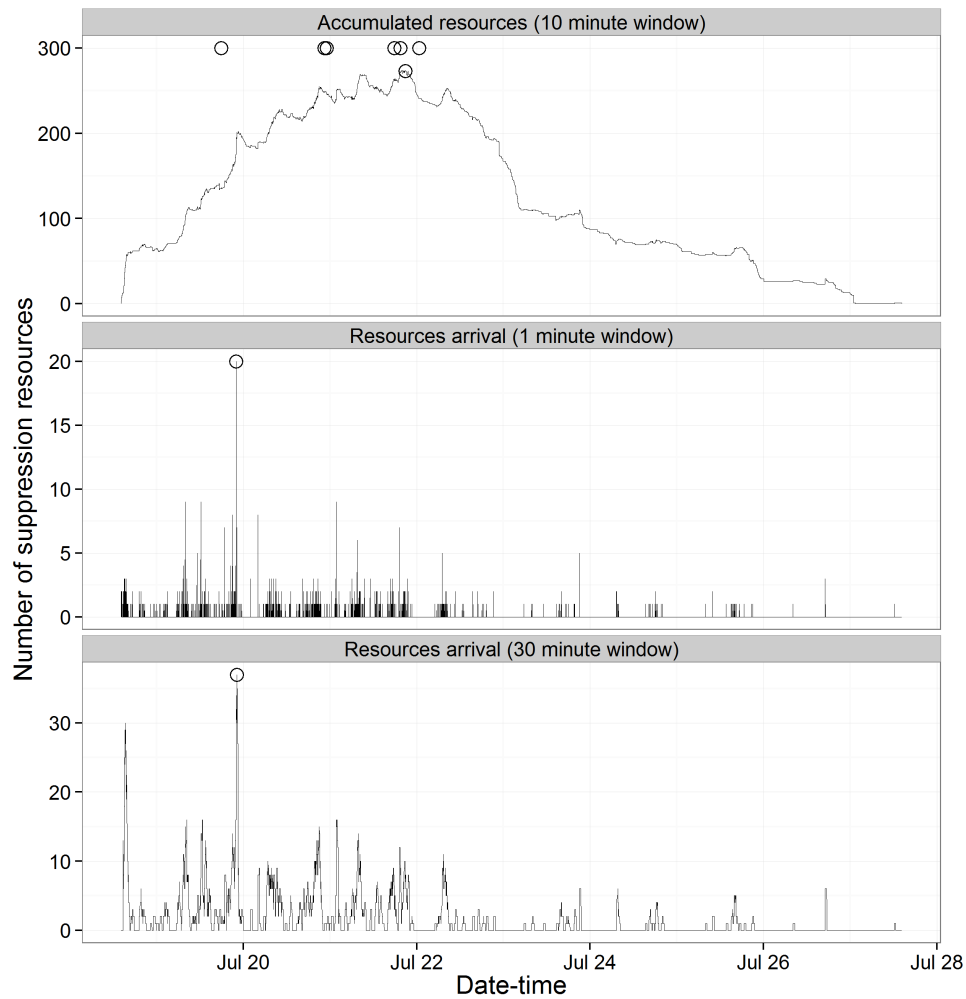


Figure 1: Accumulation and arrival of fire-fighting resources (vehicles, aircraft and personnel) in the 24.843 ha Tavira 2012 ELF: on the top panel the accumulated resources on a 10-min time window basis, the maximum or estimated T (circle, on top of the line), and the six times at which the fire was declared 'being held' (circles aligned at the top); in the middle and bottom panels, the number of dispatched resources, calculated using, respectively, one- and 30-min time windows and their maxima (circles on top of each line).

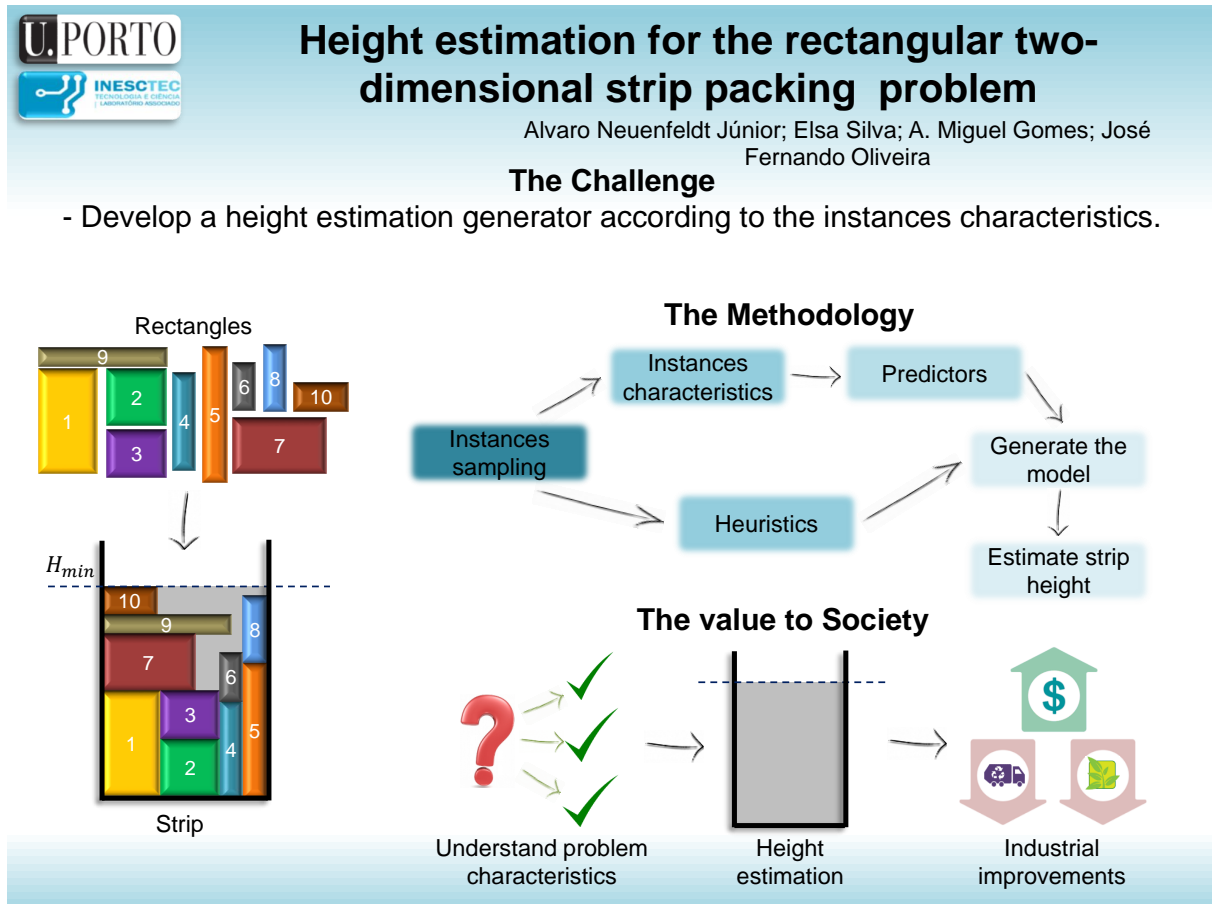
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Height estimation for the two-dimensional strip packing problem

Alvaro Neuenfeldt Júnior*†, Elsa Silva*†, José Fernando Oliveira*†, A. Miguel Gomes*†

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



1 The Challenge

In the two-dimensional strip packing problem the aim is to pack a set of rectangular items inside a rectangular object by minimizing the dimension of the object that is free. The small items must be positioned without overlapping and completely inside the object. This description fits in the definition of cutting and packing problems and indeed the strip packing problem can be classified as an open dimension problem. An example can be found in Figure 1.

Over the years a considerable number of instances appeared in the literature to test the different heuristics that have been developed to solve the strip packing problem. However, none of the developed heuristics were able to solve efficiently all the existing test instances and strip packing problem variants. The challenge of this work is to study the characteristics of each instance that may influence in the quality of the solutions obtained by the different heuristics.

The present work was conducted with its purpose is develop a classification system for the problem instances in the two-dimensional strip packing problem, capable of predicting and measuring the expected quality of the solutions obtained by the heuristics.

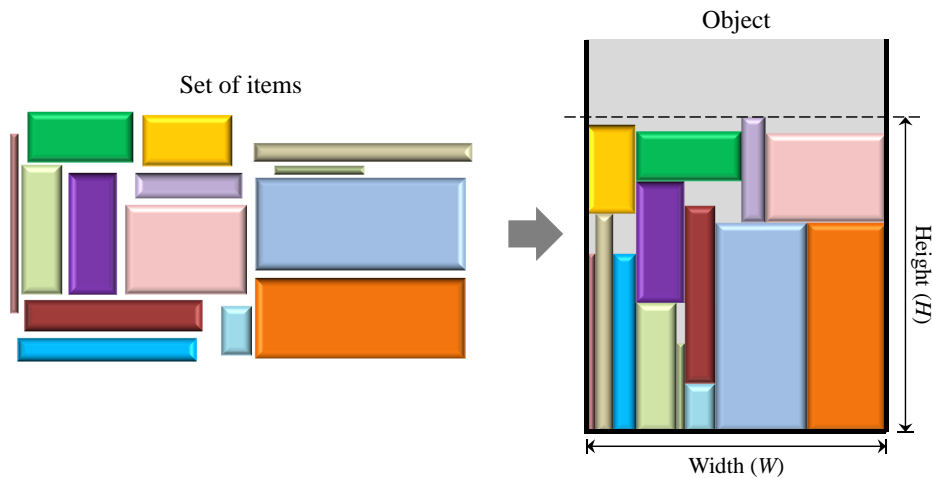


Figure 1: A general view of the rectangular two-dimensional strip packing problem.

2 The Methodology

The instances classification system considers different steps, which are summarized in the scheme found in Figure 2. Initially, it is necessary to define an instance sample (step 1) that significantly represents a high number of characteristics of the rectangular two-dimensional strip packing problem.

Several heuristics (step 2) with different constructive rules (i.e. bottom-left, best-fit and next-fit decreasing height) and improvement methods (i.e. simulated annealing, local search and greedy randomized adaptive search procedure) were used in the literature for solving different problem instances for the strip packing problem.

The measure that is usually proposed to determine if a heuristic procedure is able (or not) to solve efficiently a problem instance is the gap (step 3), that is the relative difference between the best solution obtained by the heuristic (H) and a known lower bound (LB) of the instance ($gap = \frac{H-LB}{LB}$).

A set of variables that represent the instances characteristics is defined (step 5) exploring some aspects related to the items and object shape variation (step 4), according to the behavior of the instances selected in the sampling. A trivial lower bound for all instances is also obtained by summing the area of all items and dividing it by the width of the object.

The selection of the most significant variables (step 6) is defined according to the Pearson correlation between variables and the heuristic gaps. Combinations with higher values indicate that a specific variable has higher interference in the gaps behavior.

The measure of the level of variability is defined by a linear equation $y = ax_1 + bx_2 + \dots + nx_n + c$, where a, b, n represent the relative weight of each variable x_1, x_2, x_n , the independent factor y is proposed by the heuristics gap, and c is a constant. Each weight is represented by the unstandardized coefficients calculated using a backward linear regression procedure.

All information obtained in the linear equation is used to predict the difficulty level (step 7) of each instance (proxied by the gap), and also to estimate the system error (step 8) between the predictions and the real gaps extracted of each instance. The objective is to identify if the classification system developed is adequate to the instance sample characteristics.

To test the method developed, a set of 1220 instances from the literature were solved by two different heuristics, generating four variables after applying Pearson correlations: instance heterogeneity, instance

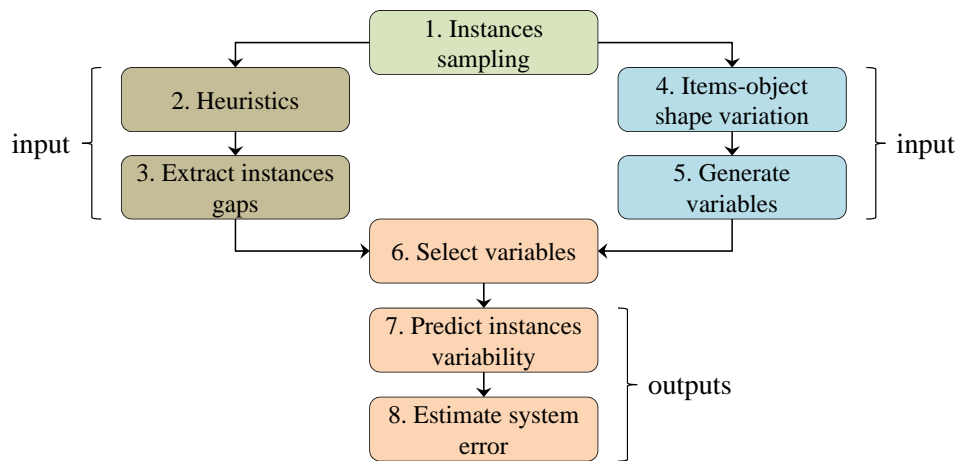


Figure 2: Method steps.

coefficient, item-object width proportion and item-object dimensions proportion, with a mean absolute percentual error of 0.1 between the gaps predicted and real values.

3 The value to Society

The rectangular two-dimensional strip packing problem can be found in many industrial applications. For example, in the sheet metal industry, where the rolls are divided into rectangular items, in the textile industry, where the fabric should be cut in smaller pieces, and in optic fiber communications, during the memory allocation storage process.

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

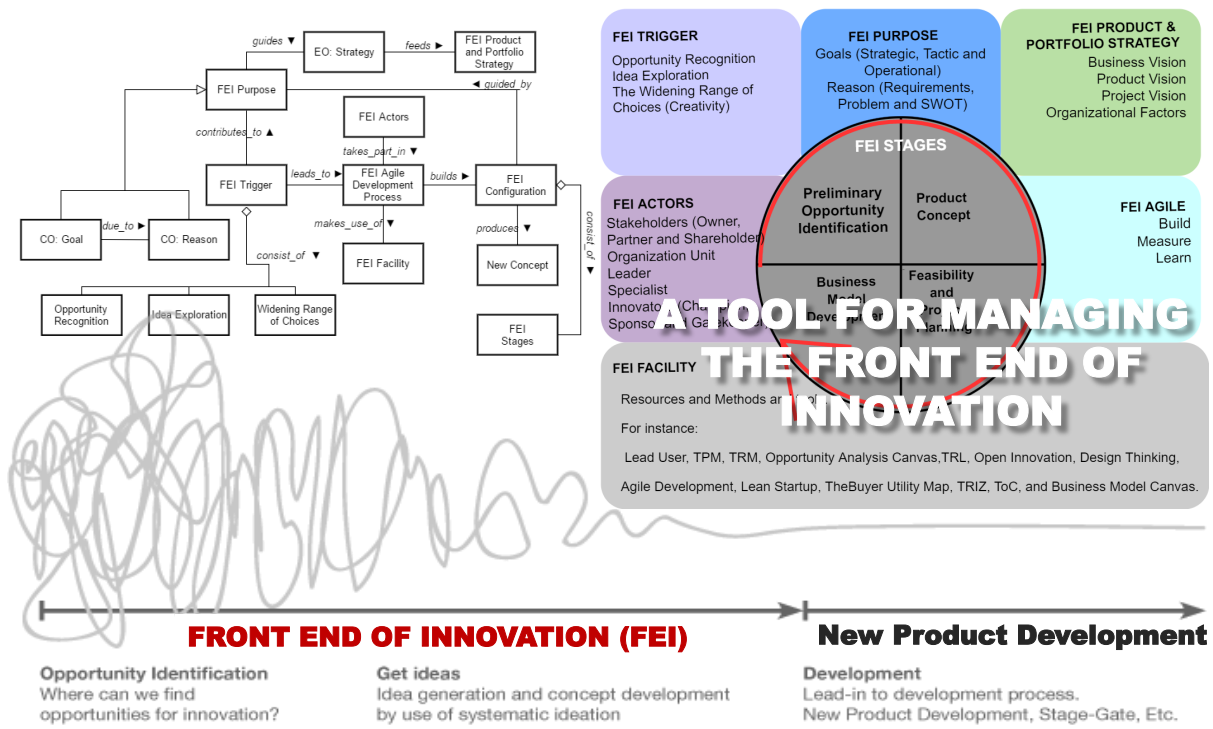
The instances classification system helps in the development of more efficient heuristics for solving the strip packing problem, by providing a more accurate information on the characteristics of the problem. It also facilitates the development of new problem instances with the aim of overcome the drawback of some missing characteristics in the existing instances in the literature.

An Integrative Front End of Innovation Ontology

Ariane Rodrigues Pereira*[†], João José Pinto Ferreira*[†]

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**from the
FORMAL FEI MODEL we derive...**



An Integrative Front End of Innovation Ontology Ariane Rodrigues Pereira
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1 The Challenge

The global economy has been facing difficult challenges over the last years. This has impacted markets, industries and consumers. Beyond the economic issues, organizations also have been facing the challenge to keep up with the technological changes. As a result, it is more than ever vital for companies, either large or small, to innovate and grow. It is widely accepted by business leaders the relevance of innovation, however, research has pointed out the difficulty that businesses face in developing innovative products and services. Between 80-90% of new product launches typically fail and a great amount of business leaders are displeased with their ability to innovate.

Companies have been investing in the organization of their Innovation Management processes (“doing the things right”), but many times failed to look into the so-called Front End of Innovation. The beginning of the innovation process, also known as a Front End of Innovation - FEI or Fuzzy Front End, is about doing the “right things” in innovation and aims at increasing the probability of success of the concepts

developed for commercialization. The nature of FEI activities are known to be experimental and chaotic, involving unstructured and Ad-Hoc decisions. This is also reflected in the literature where authors look at the FEI from many different perspectives, due to its evident multidisciplinary nature, but also propose different models, seldom overlapping, thus hampering the construction of a common reference model and language for the FEI. This research aims at overcoming this issue by proposing a FEI Ontology.

An ontology is an explicit specification of a conceptualization and is used to define a common vocabulary for researchers to share information in a domain, but is extensible for experts and practitioners. Ontologies provide a formal model for domain knowledge. The FEI Ontology is being used for the consistent and comprehensive representation of the early activities of the innovation process. This will lead to the development of an Integrative FEI Canvas to be used by experts and practitioners.

2 The Methodology

This research follows the Design Science to the development of the FEI Ontology. This strategy was adopted as it enables the problem-solving paradigm, providing the adequate approach for answering the research questions: To what extent would it be possible to build an ontology of the FEI knowledge domain? And, which entities would compose the FEI model?

The Ontology development and validation, is clearly the main task at hand. This process entails the following phases:

- The *Feasibility Study* identified as a problem the absence of a common language for the FEI. It was also characterized the domain of the ontology and selected the focus and targeted solutions. The Ontology Requirement's Specification, carried out at this stage, includes the identification and definition of the so-called competence questions.
- The *Ontology Kickoff* among other tasks involved the development of the requirements specifications, the input source analysis, as well as the development of the baseline taxonomy.
- The *Refinement Phase* established a framework for the ontology structure; ontology encoding and formation; conceptualization and formalizations; the definitions of relations and axioms; and, the concept elicitation with domain experts. The cognitive testing approach was used in this phase for term and vocabulary validation.
- The *Evaluation Phase* is ongoing and responsible for the revision and expansion of the ontology based on feedback. The cognitive testing is still being used. In this phase we analyze the patterns of use, the ontology assessment and confirmation and, at last how experts perceive the way the ontology meets the competence questions.
- These phases are followed by *Maintenance Phase* that includes optimization and reuse of the ontology.

3 The value to Society

A recent study pictured that the Front-end success was actually the strongest independent predictor for all of the NPD performance variables. This study by Stephen K. Markham from the NCSU (USA), analyzed 272 companies to test the hypothesis that front-end performance impacts new product performance in the marketplace while controlling for new product development (NPD) processes and strategy. The data support the hypothesis that front-end performance favorably and independently impacts overall product success, time to market, market penetration, and financial performance.

The present research will result in two main outcomes: 1) to the literature: the first proposal of a comprehensive FEI model, covering all known perspectives under which it has so far been analyzed Figure1;

2) to industry: the first comprehensive tool and supporting methodology to address the organization and enactment of FEI flow and FEI activities, Figure 2 illustrates a preliminary version of the Integrative FEI Canvas.

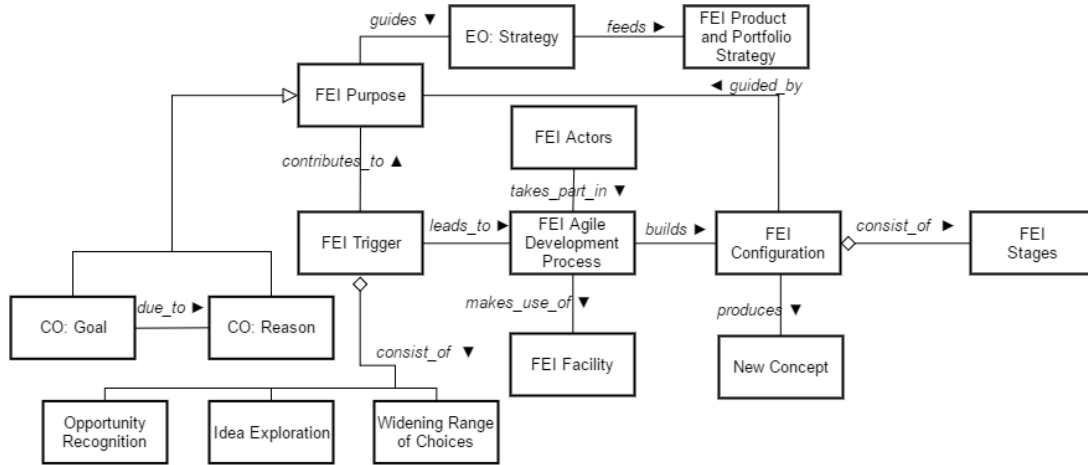


Figure 1: High-Level Ontology - Inter domain Main Relationships

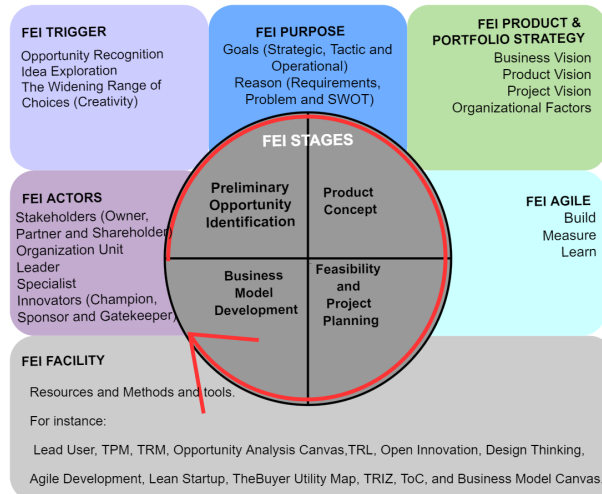
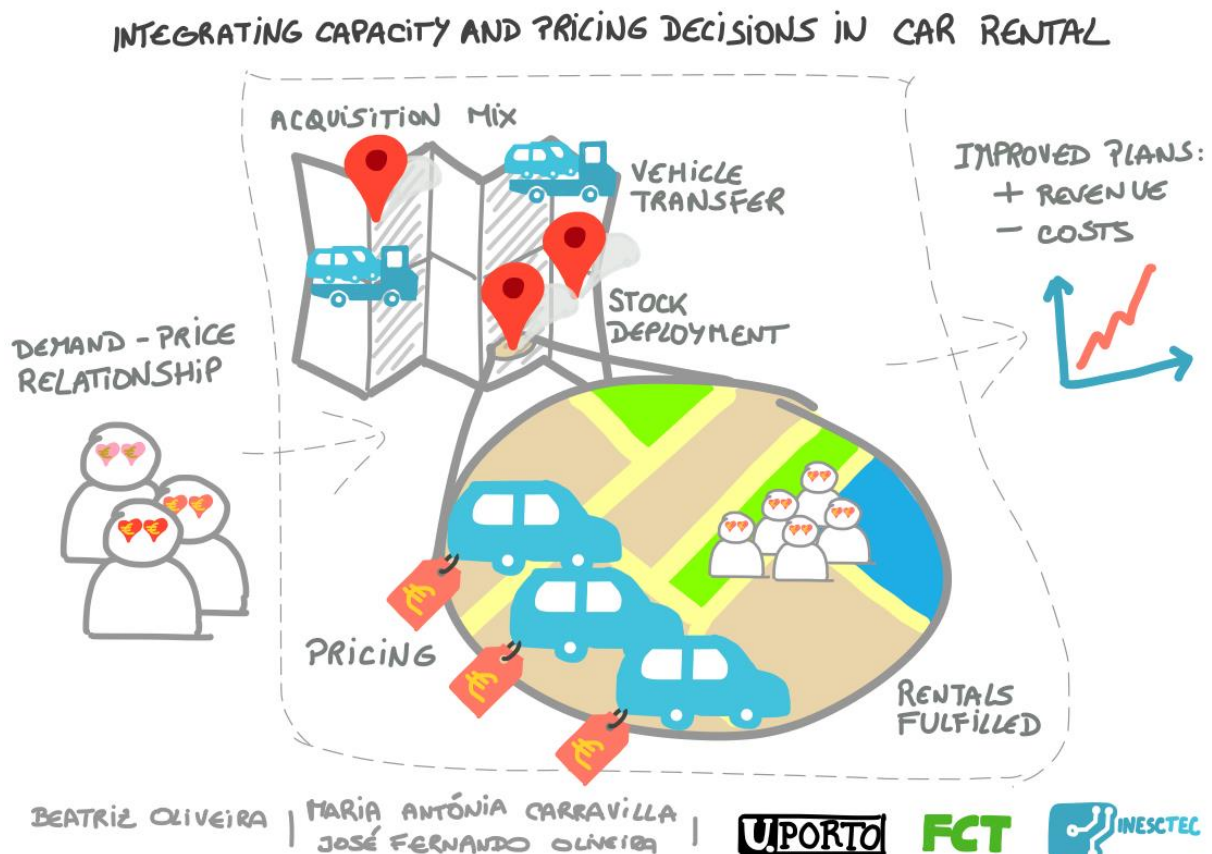


Figure 2: Integrative FEI Canvas

Integrating pricing and capacity decisions in car rental companies

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1 The Challenge

The car rental business is a relevant and interesting field of study due to the challenging characteristics of its fleet and decision-making processes, which are structurally different from traditional transportation sectors, and to a significant growth witnessed in this sector in past years and expected on a near future.

One of the most interesting characteristics of this business is that decisions that are usually tackled separately, such as product pricing and capacity decisions (which involve, e.g., decisions on acquisitions, fleet size and mix, among others), are not only linked by close interactions but also by overlapping decision-making time horizons. This is partly due to the inherent flexibility of the fleet, enabling the use of “empty transfers” to balance available fleet and demand. This flexibility is extended to the fleet size, since besides owning a more stable fleet, the companies also may establish flexible leasing contracts to deal with demand peaks and uncertainty. Moreover, this is a very competitive business and pricing plays

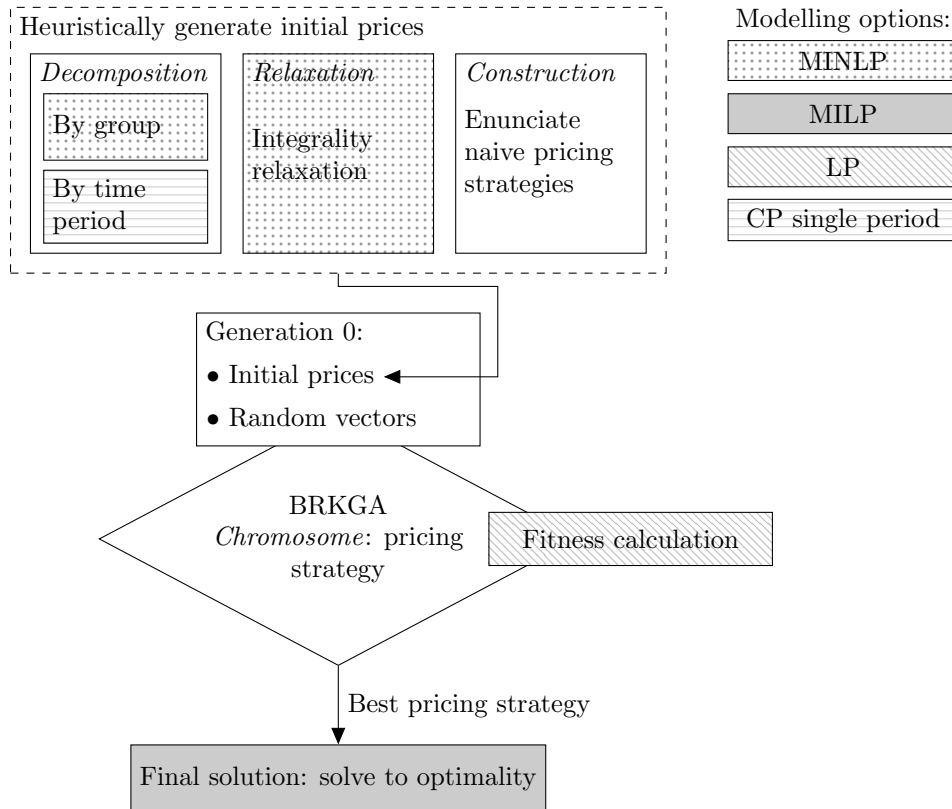


Figure 1: Solution method overall structure.

a major role on the company's profit. In this context, revenue management decisions are significantly impacted by capacity decisions (and vice-versa).

The integration of operational and revenue management decisions for flexible mobility systems, such as this, is not yet significantly tackled in the literature. Therefore, this work aims to fill a research gap and tackle the integration of pricing and capacity decisions. This problem considers the length of a sale season (from 1 to 3 months) and the goal is to propose a good fleet acquisition plan and pricing strategy for the season at stake.

2 The Methodology

The problem described above was modelled as a Mixed Integer Non Linear Problem (MINLP). This problem considers multiple time periods, multiple rental zones, and interacting upgradable vehicle groups. The main decisions are related to vehicle acquisitions – both in terms of owned fleet (one-time decision, at the beginning of the period) and leased fleet (a more flexible decision, that can take place any time throughout the horizon) – and with the price charged per each reservation type at a given antecedence. Moreover, other decisions derive from these, as the number of fulfilled reservations (upgraded or not) and the stock of vehicles in each rental zone and time period must be tracked, as well as any empty transfers needed.

The goal of this model is to maximize the company's profit considering the revenue received from the fulfilled reservations, the costs of maintaining and acquiring the owned fleet, leasing costs, empty transfer costs, and upgrading costs. The main constraints of this problem are related with the control of the stock of leased and owned vehicles in each zone and time period, the demand (dependent on the pricing decision), the upgrading rules and the overall budget for buying vehicles.

Since this multi-period MINLP model is significantly complex and hard to solve for real-sized instances, especially due to the non-linearity of the objective function, a solution method was proposed to obtain

good quality solutions within a reasonable time-frame (Figure 1). This solution method can be considered a meta-heuristic, since it uses a (population-based) meta-heuristic to guide the search over the decomposition of the original mathematical model. The overall idea of the method is to decompose and simplify the original model by fixing the price and solving the resulting model for different pricing strategies. This is based on the fact that, if the price is a fixed input and not a decision variable, the problem becomes a Mixed Integer Linear Problem (MILP) and hence easier to solve.

A Biased Random-Key Genetic Algorithm (BRKGA) was used to guide the search for these pricing strategies, which were translated into chromosomes. The value of each pricing strategy is the result of solving the MILP model with the price input fixed. However, in order to accelerate the procedure, an approximation was used to evaluate each chromosome's fitness: the linear program (LP) resulting from relaxing all integrality constraints.

Furthermore, specific knowledge about this problem, such as the natural decomposition scheme that arises from forbidding upgrades, was used to improve the performance of the BRKGA's search for good pricing strategies. Initial heuristic solutions were generated and fed into the (usually entirely random) generation zero. These solutions were obtained by: *decomposition* (by vehicle group and by time period), *relaxation* of integrality constraints, and *construction* of naive strategies. When the available tools hindered the generation of the heuristic solutions, other modelling options were studied. As a result, a Constraint-Programming single period model was also developed to obtain initial solutions by *time period decomposition*.

3 The value to Society

The main contribution of this work is that it modelled and solved a relevant integrated problem, which is usually solved by car rental companies in an unconnected (at most, hierarchical) manner, thus achieving significant cost savings as far as fleet management is concerned and significant revenue boosts on the pricing side. A sequential baseline approach was thus developed in order to be the comparison threshold for the performance of the integration strategy versus a more "traditional" hierarchical decision process.

Moreover, a decision support system can be designed based on the work herein presented, which can be used by companies to run what-if analyses when preparing a new sales season (e.g. 'what if the budget for purchases is doubled?', or 'what if the length of the leasing contracts increases?').

From the academic perspective, this work is relevant not only because it proposes a model to a new problem but also because it pushes forward the research on meta-heuristics applied to operations management problems, by validating the potential of using population-based meta-heuristics to guide the resolution of mathematical models, especially when enhanced by initial heuristics that benefit from specific knowledge of the problem.

Information management in supply chain: a model to support risk management decisions

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Information management in supply chains: a model to support risk management decisions

TELL ME DARIO,
WHAT ARE THE
CHALLENGES IN
THE AIRCRAFT
PRODUCTION
SUPPLY CHAIN?

AND WHAT
METHODOLOGY
WILL YOU USE?

OK! BUT DARIO,
WHAT IS THE
REAL VALUE TO
SOCIETY?



WELL, SIR BRANSON THERE ARE SEVERAL:
PARTNERS GLOBALLY DISPERSED;
HUGE ENTRY BARRIERS;
LONG PRODUCT DEVELOPMENT
CYCLE;
STRICT PROCEDURE FOR
QUALIFICATION AND CERTIFICATION

I'M USING DESIGN SCIENCE
RESEARCH PARADIGM:
LITERATURE REVIEW;
EXPLORATORY FIELD RESEARCH;
CASE STUDY RESEARCH.

IMPROVEMENT OF DECISION-MAKING
CAPABILITY OF AERONAUTIC SUPPLY
CHAIN'S FIRMS TO FACE RISKS, AND
INCREASE AWARENESS OF SUPPLY
CHAIN RISKS THROUGH THE ADOPTION
OF THE INFORMATION MANAGEMENT
MODEL.

IEMS '17 –
8th Industrial Engineering and Management Symposium

Dario Messina | Ana Cristina Barros | António Lucas Soares

1 The Challenge

During the past decades the world has experienced remarkable events that highlighted the severe effects disruptions can have in supply chains (Nokia vs Ericsson, World Trade Centre's terrorist attack, the world financial crisis, Fukushima's nuclear plant disaster, and Nepal's earthquake). The interest of risk management in supply chains arose from these events and has been strengthened by the research community during the last years. Furthermore, the context in which firms have to operate is characterized by a series of sources of uncertainty, due to market globalization and increasing complexity that results in additional risk exposure for supply chain members.

Supply chain risk management (SCRM) has been defined as the identification and management of supply chain risks through coordination or collaboration among supply chain partners to reduce supply chain vulnerability as a whole, thus ensuring profitability and continuity of the chain. As stated in the definition, the first action to undertake is the identification of the different types of risk to which the chain is

exposed. Once supply chain risks have been classified, mitigation strategies to these risk types are linked with decisions involved in each of these processes. Therefore, in order to support decision making for risk mitigation, companies need visibility over the specific process of interest. Even if the benefits related to enhanced visibility have been highlighted several times from the academia, a supply chain visibility (SCV) model, a conceptual model, tailored for decision-making in SCRM is still missing.

Furthermore, many researchers identify a strong link between SCV and Information Management (IM), highlighting the vital need to gain visibility when members need to share information across the supply chain. This strong link can be found starting from the definition of SCV itself. Some researchers see it as information sharing synonymous or as a first output of the broader IM process. An information management model (IMM) for SCRM results from the study of the relations between information management and the decisions related to mitigate supply chain risk.

The model is going to be applied in several firms belonging to the aeronautic supply chain. First of all, the aeronautic sector is considered one of the most strategic sectors for the growth of a country. In 2015 it contributed for the 3.5% of the global gross domestic product (GDP) and forecasting shows a growing trends until 2032. Secondly, and most important in terms of relevance of this thesis work, compared to other complex SC context, the aeronautic sector shows unique characteristics such as, huge entry barriers, long product development cycle, very strict procedure for qualification and certification that making even more complicated the selection of alternative suppliers due to risk sharing partnership, generally lasting between 20 and 30 years.

2 The Methodology

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

Figure 1 shows the characterization of the activities, embedded in each of the three main blocks of the DSR paradigm, necessary for the development of this thesis project. The operational implementation of the activities in Figure 1 is based on the process proposed by Peffers et al., in order to conduct the analysis and avoid omissions or imprecisions. The descriptions of the five activities considered and their application is explained in what follow.

- Problem identification and motivation: allows defining the research problem and explaining the value of the solution proposed. Exploratory literature review to analyse the characteristics of the aeronautic sector, understand how information is managed in supply network, the consequences of supply chain visibility, and the fundamental concepts of supply chain risk management. Exploratory field study to understand how information flows within the supply chain and how this information is organised
- Define the objectives for a solution: in which we define the scope of our solution and evaluate existing solution. Exploratory study through interviews to evaluate the feasibility of some technical solutions, in order to identify the adequacy of some solutions in meeting clients' business needs, the types of risk they allow to face, and the related information needed.
- Artifact design and development: is the peculiarity of DSR paradigm and it allows identifying the requirements needed to build the IMM for the aeronautic sector .
- Evaluation: it allows demonstrating the ability of the artifact in solving specific problems and evaluating its efficiency. Interviews to refine the requirements of the IMM and definition of design propositions.
- Communication: through which we disclose the relevance of the project both to researchers and practitioners. The realization of two journal papers and a doctoral thesis will allow accomplishing this task.

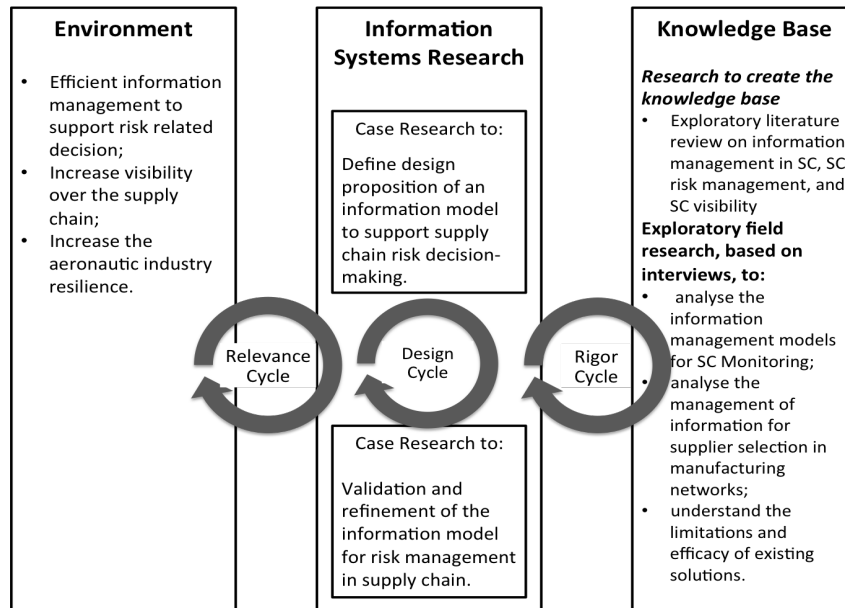


Figure 1: Design Science Research framework

3 The value to Society

The topic of information management in supply chains has been extensively studied in the past. The information management model provides a multi-view and aggregated model of internal and external information for decision support in supply networks in the aeronautic sector.

This doctoral thesis aims at contributing with new insights at the intersection of the research areas of information management and supply chain management. In particular, expected results include the improvement of decision-making capability of firms belonging to the aeronautic supply chain to face risks, and to increase awareness of supply chain risks through the adoption of the information management model.

Acknowledgement

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

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

Débora de São José, Nuno Fidalgo

The Challenge

Previsão das mudanças climáticas no Brasil até 2100
Cientistas estimam aumento de até 6°C na temperatura se emissão de gases permanecer alta

Região	TC (°C)	Redução de Chuvas (%)
AMAZÔNIA	TC a 6°C	Redução de 10% a 45%
CAATINGA	TC a 4,5°C	Redução de 10% a 50%
MATA ATLÂNTICA (Porção Nordeste)	TC a 4°C	Redução de 10% a 35%
PANTANAL	TC a 4,5°C	Redução de 5% a 45%
CERRADO	TC a 5,5°C	Redução de 10% a 45%
PAMPA	TC a 3°C	Redução de 5% a 40%
MATA ATLÂNTICA (Porção Sudeste)	TC a 3°C	Redução de 5% a 30%

Infográfico elaborado em 09/2013

The Methodology

- Literature review
- Data collection and analysis...;
- Implementation of the system's components model;
- Climate's projections in Brazil and modelling of the impacts;
- Analysis of the smart grids' expected impacts in these scenarios, etc.

The Value to Society

- ↑ Energy efficiency (5% more efficient=~R\$350.097.175,70)
- ↓ Theft and fraud (1% reduction = economy of ~ R\$22.834.000,00)
- ↑ Competition in the electric sector
- ↑ Security of supply
- ↓ Use of pollutants sources
- ↑ Integration of renewable distributed generation
- ↑ Management on the consumption
- ↑ Reconciling targets for climate-change
- ↓ GHG emission and energy consumption

1 The Challenge

The climate is always changing. However, in the last few decades, human activity has been intensifying this natural process by adding more greenhouse gases into the atmosphere. The electricity sector is one of the main responsible for that changes and the renewable generation is seen as a way to mitigate the effects. In Brazil, the power sector has been mainly renewable, almost since its creation, but the systems with large share of renewables are more vulnerable to the effects of climate change.

The hydro generation has been decreasing due to unfavourable hydrological conditions and the thermal generation has been increasing to supply the demand. Therefore, the GHG emissions per MWh produced are increasing every year.

Smart Grids technologies may help to adapt the power sector to the observed changes and mitigate the emissions caused by the use of non-renewable sources.

2 The Methodology

Smart grid is a much-commented topic by energy sectors, governments and research institutes. A smart grid can be seen as a grid that uses information technology, which allows two-way communication, more efficient transmission, faster restorations, etc.

Developing a smart grid would allow to increase the flexibility of capacities management for growing demand; to accommodate new sources of energy with bidirectional and flexible grids; to allow new players to participate in new energy markets; to reach the climate goals in the most developed and under development countries.

The research was divided into three steps.

The first step consisted of a review of specialized literature, namely on reports produced by governmental and intergovernmental research institutions on climate change and mitigation measures commonly adopted, including the transition to smart grids. The outcome of this step is a portrait of the status quo of climate changes in Brazil as well as the identification and characterization of climate mitigation procedures. From that, it was possible to conclude that, the power industry in Brazil has been always in struggle with many past crisis and also, being one of the main obstacles for the countries development. Also, considering the climate impacts, the wind generation capacity is expected to increase in the north of Northeast region, and the hydroelectricity generation capacity decreases, especially in the basins located in North and Northeast of Brazil, and this loss in hydroelectricity generation may exceed 80

The second step includes the collection and organization of the data, which will be used during the step three in modelling and system characterization. This step provided a good description of the sector and its evolution in the last 45 years, the high participation of hydro source in the past, the increase on thermal sources (especially the natural gas), the critical situation of the main reservoirs for hydro generation, etc. It was also analysed the flow rate of rivers that are relevant for hydro generation during the last 80 years and some climatic data, as average maximum and minimum temperature and precipitation.

In the last step data mining techniques and simulation will be applied to analyse a set of possible scenarios and estimate the potential impact of climate change in Brazil, with and without smart grids.

Therefore, the ongoing work is to identify the:

- Correlation between variables;
- Implementation of the components of the system model (installed capacity; costs; GHG emissions; efficiency; losses; Brazilian energy plan; and others)
- Climate projections in Brazil and modelling of the impacts;
- Analysis of the expected impacts of smart grids in these scenarios, etc.

This presentation will address the scenarios for: (1)climate change, (2)future of power sector and (3)smart grids implementation in Brazil. It also will address the expected impacts of climate change in the power generation and consumption and the likely impacts of the use of smart grids in the country.

3 The value to Society

If smart grid shows itself as able to mitigate the GHG emission in the Brazilian power sector and adapt the sector to the observed effects it will contribute to:

- Reduce the changes in the climate: by reducing the amount of gases in the atmosphere as it enables the increase of renewable sources participation in power generation by, for example, the use of distributed generation;

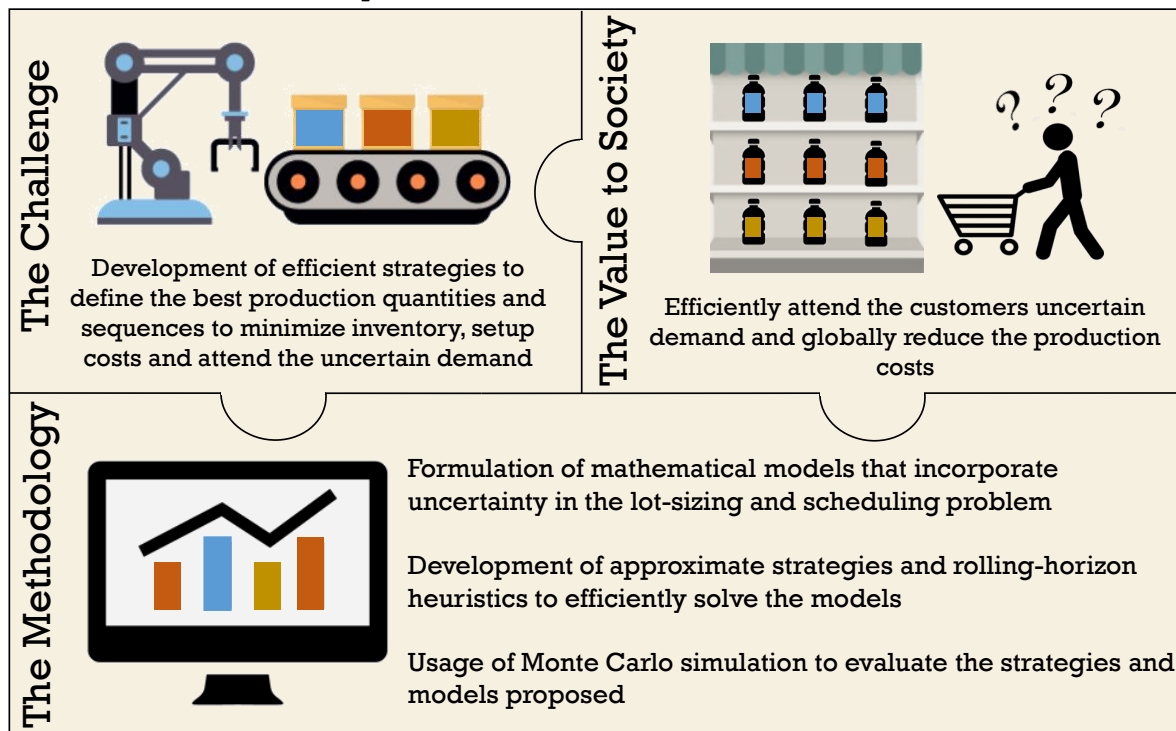
- Increase the security of supply: as consumers will be able to help balancing supply and demand and modify the way they use and buy electricity, by reducing the peak load and, also, because smart grids provides the system with abilities to react to unexpected events by isolating problematic elements while the rest of the system is restored to normal operation;
- Reduce the peak load: in UK, Ireland and USA, pilot projects was achieved a reduction between 5 and 15 percent being the bigger one from the US energy department by the use of a sophisticated system that responds to simple instructions set by a consumer;
- Reduce the network losses: a distributor utility implemented smart meters in regions with very high losses levels in Brazil and achieved a reduction in non-technical losses of 4,73 percent in 4 years, besides, the working group on smart grids in Brazil also expect a reduction of 9,6 percent in low voltage technical losses; and
- Reduce the power system exploitation costs: as it is expected to reduce de losses, enable the increase in renewable participation, reduce interruption of services, etc.;

Solving the General Lot-Sizing and Scheduling Problem under Dynamic and Uncertain Demand

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Solving the General Lot-Sizing and Scheduling Problem under Dynamic and Uncertain Demand



1 The Challenge

Generally, the lot-sizing and scheduling problem aims at defining the best production quantities and sequences for a set of products in order to minimize the inventory and setup costs. One of the most well known formulation is the General Lot-sizing and Scheduling Problem (GLSP). The problem has been widely addressed by the scientific community, since past researches showed the main benefits and practical applications of integrating lot-sizing and scheduling decisions. Moreover, recent advances in solving efficiency of lot-sizing and scheduling (L&S) problems made possible applications on large and industrial scale settings.

Nevertheless, there is a lack of works that consider uncertainty in L&S problems. The importance of uncertainty in these problems is noticeable as for instance, demand uncertainty can substantially increase

the shortage of products, or uncertainty in production processing time may yield infeasible production plans. Production planning models that incorporate uncertainty can drastically reduce expected costs, risks and also avoid infeasible decisions. Following this line, we aim to study strategies to efficiently address demand uncertainty in the GLSP, considering a flexible production system, where scheduling, production and inventory decisions can be adjusted in every period.

One of the main modeling techniques to tackle exactly the GLSP under uncertainty is the multistage stochastic programming. This approach incorporates uncertainty into the model using an assumed demand distribution to generate discrete scenarios over the stages. Its main drawback is that it is usually intractable and can demand highly computational efforts, especially when there are many scenarios and/or stages. An alternative modeling approach that can also be used to solve the problem exactly is the so-called adjustable robust optimization. In this approach, uncertainty is modeled using polyhedral sets, and affine rules incorporate the multistage aspect into linear variables. Nevertheless, this approach is still intractable for formulations that contain integer or binary variables, such as the GLSP. Hence, given the intractability of those modelling techniques, many authors resort to hierarchical approaches, heuristics and metaheuristics methods to solve the problem.

Despite the numerous methods and modeling approaches to tackle uncertainty in the GLSP, there is an absence of works that assess and compare solving strategies and modeling approaches that address uncertainty. These modeling approaches have several variations and different parameters that directly impact on their performance (e.g., budget of uncertainty, number of scenarios), in addition to the characteristics of instances. These two aspects increase the difficulty in assessing the benefits of each approach and, therefore, in comparing different models and strategies for L&S problems under uncertainty.

Hence, this research addresses two main challenges. The first is the development of strategies and models that efficiently provide high quality solutions for the GLSP under demand uncertainty. The second is the creation of an efficient and systematic evaluation method that quantitatively compares the strategies and models proposed.

2 The Methodology

In this work, we propose two heuristic strategies and four models using robust optimization and stochastic programming approaches in order to solve, in a more tractable manner, the GLSP under demand uncertainty with possibility of adjusting scheduling, production and inventory decisions in a rolling-horizon scheme. In addition, we develop a standard multistage stochastic programming model and a deterministic model with safety stocks. These models are traditional methods to tackle the demand uncertainty in lot-sizing problems and will be used as a comparison basis for the strategies proposed.

Our first strategy proposes an adaptation of the static robust optimization and the two-stage stochastic programming models to the multistage setting, which allows production, scheduling and inventory decisions to be readjusted in every period. Basically, this strategy applies these modeling approaches within a rolling-horizon planning scheme. This adaptation strategy was previously shown to be adequate in efficiently solving stochastic problems with a small impact on solution quality. Nevertheless, it has never been applied to robust optimization models nor to the GLSP models, which is the focus of this work.

The second strategy approximates intractable models (such as, multistage stochastic and adjustable robust optimization models) to simpler and easier models to solve. Essentially, this strategy uses a rolling-horizon planning scheme and relaxes the integer scheduling variables for the future periods (succeeding the current one). This is possible because decisions of later periods are never implemented in the actual period in a rolling-horizon scheme. Hence, it allows for a simplified version that is easier to solve. This approximation strategy has only been applied to deterministic models in a rolling-horizon planning scheme, in which its rapid solving efficiency was shown. We intend to apply this strategy to solve the multistage intractable models in order to improve their solving performance and solution quality for large scale instances.

To compare the performance of the strategies and models proposed we develop a Monte Carlo experiment that simulates the demand for each period and evaluates the models solution. The experiment is

performed in the following way: (1) the demand of the current period is revealed; (2) the model is solved with the current demand information available and only the information of mean and standard deviation from future demands known; (3) after the model is solved the decisions of the current period are fixed; (4) the next period becomes the current period and the simulation goes to step (1). This iterative scheme proceeds in this manner until the demand of all periods is revealed and all the decisions variables fixed.

After a considerable number of replications of the simulation it is possible to calculate the performance of each model in terms of average, standard deviation, worst-scenario and runtime. We perform 100 replications of the simulation procedure and test several parameters (e.g., safety stock level, budget of uncertainty, variability level and number of scenarios) for each model/strategy and each instance in order to achieve a valid statistical experiment.

3 The value to Society

The value of this research to the general community is delivered by the benefits of the new strategies and new models to efficiently solve the GLSP in a demand uncertainty setting. Higher solving efficiency and better solution quality allow for the application of uncertainty models on an industrial scale. This can lead to practical gains and strategic advantages for companies that face critical uncertainty sources such as, globally reducing the total costs of scheduling, production and inventory, and at the same time, effectively attending the customers uncertain demand.

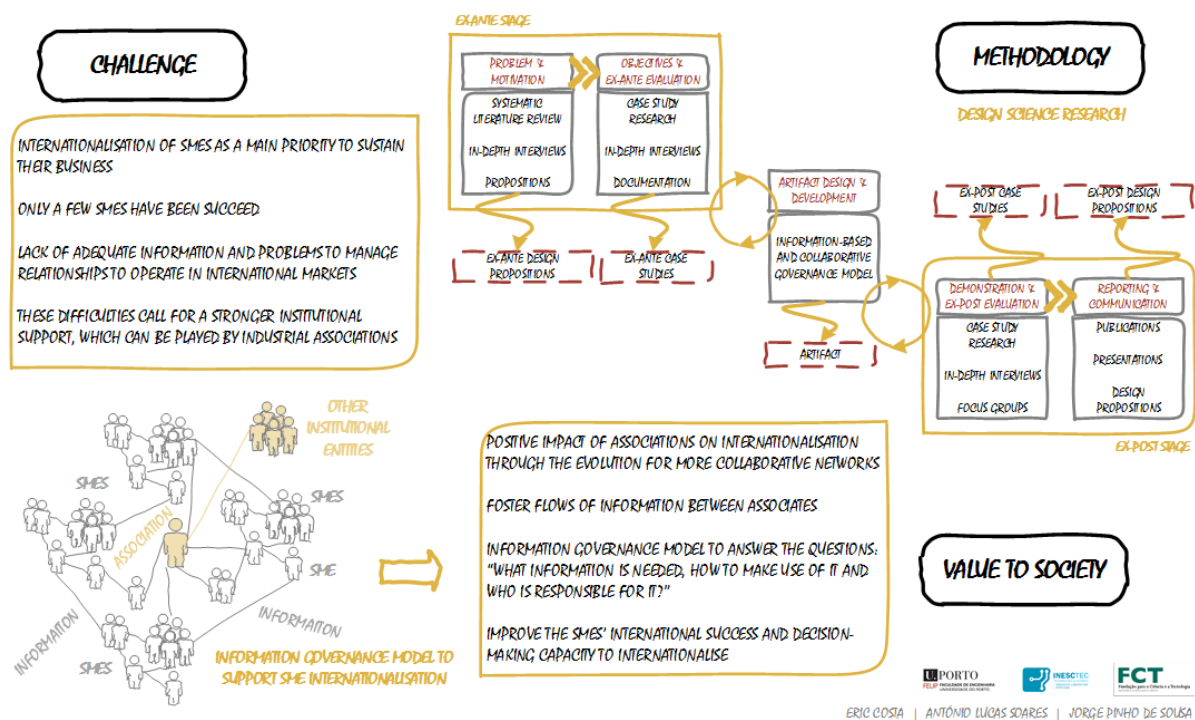
The value to the scientific community is related to the outcomes of the simulation method developed for comparing different models and strategies proposed. With this method, it is possible to analyze the main trade-offs among the strategies that tackle uncertainty in terms of average cost, risk and computational complexity. This work should also help to understand how uncertainty parameters and instances characteristics impact on each strategy and modelling approach, which allows for choosing an adequate strategy or model according to different circumstances or preferences.

Information management and collaborative networks of industrial enterprises associations to support the internationalisation of SMEs

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INFORMATION MANAGEMENT AND COLLABORATIVE NETWORKS OF INDUSTRIAL ENTERPRISES ASSOCIATIONS TO SUPPORT THE INTERNATIONALISATION OF SMES



1 The Challenge

Globalization of markets and the consequent rise of competitive pressure lead small and medium enterprises (SMEs) to look at internationalisation as a main priority to sustain their business. However, only a few number of firms have been succeed in internationalise to foreign markets. In comparison to large and multinational enterprises, SMEs are typically regarded as resource-constrained, lacking adequate information and facing problems to establish and manage relationships to operate in a sustainable way in international markets. To increase their chance of going international and compensate the lack of information about foreign markets, SMEs can establish contacts and form networks and collaborations with different types of social, business and institutional entities. But the problem is on how to manage,

filter and convert information from collaborative networks, into valuable knowledge for making better decisions in internationalisation.

Despite receiving some support from governments and from other institutional entities, these difficulties faced by SMEs call for a stronger institutional support, which can be played by industrial enterprises associations (IEAs). In many European Union countries, IEAs have been gaining great importance for their associated companies, mainly for SMEs, by supporting their internationalisation processes. However, the awareness of public support programmes and the use of institutional networks among SMEs is still low. Moreover, although representing most of the total number of enterprises in Portugal, only a small percentage of SMEs are actively involved in international operations. In addition, previous literature also does not pay much attention to the role of IEAs in internationalisation.

Therefore, this doctoral project is studying IEAs as institutional network support for the internationalisation of their associated SMEs. The objective is to understand the problems and the needs from both IEAs and SMEs, as well as to analyse the network dynamics that are formed through this institutional-based business environment. The ultimate goal is to design an information-based and collaborative governance model, in order to both improve the decision-making capability of SMEs to internationalise and empower IEAs for acting as a fundamental institutional support by establishing collaborative networks of internationalisation.

2 The Methodology

This doctoral project is developed on the intersection of two main research areas, International Business (IB) and Information Management (IM), and has two complementary approaches: an exploratory-oriented approach; and a design-oriented approach. Therefore, to encompass this multidisciplinary nature, the project is conducted and its outcomes are analysed and validated following the Design Science Research paradigm. The result is then a doctoral project divided in three main stages of research (Figure 1): (i) ex-ante stage (define the problem and express the motivation for the study; define the objectives of the artifact and perform an ex-ante evaluation); (ii) artifact design stage (design and develop the artifact); (iii) ex-post stage (demonstrate the artifact and perform an ex-post evaluation; report and communicate the results).

The project is currently at the end of the exploratory stage. A systematic literature review was already performed and published by reviewing relevant literature on the role of information, knowledge and collaboration in the effectiveness of making decisions in internationalisation processes of SMEs. The adopted approach followed five steps: (1) question formulation; (2) locating studies; (3) study selection and evaluation; (4) analysis and synthesis; (5) reporting and using the results. The following highlights were obtained: (i) lack of studies addressing information management in internationalisation of SMEs; (ii) no evidence on how SMEs can convert information into knowledge for making decisions; (iii) collaboration is not well explored for more effective internationalisation outcomes; (iv) new information and knowledge models are needed to improve internationalisation; (v) collaborative decision-support models are required for better internationalisation.

After that, a first exploratory study was performed by interviewing five Portuguese industrial companies to understand their perspective about the role of IEAs as information managers and promoters of collaborations and about the use of collaborative platforms for supporting their internationalisation activities. Empirical evidence was collected using personal semi-structured interviews with different kinds of interviewees, such as CEOs, CCOs, and advisors. These companies were selected to have a sample representing different types of organizations: two large enterprises, two SMEs and one startup. The main findings of this study are: (i) IEAs can improve their role in the promotion of more collaborations between their associated companies; (ii) a collaborative platform managed by IEAs may foster information sharing and also sharing of experiences between associates; (iii) nevertheless, there is important aspects to consider for developing these solutions, such as the informational needs, governance model, information organisation, information life-cycle, usability of the solution and informational behaviour of decision-makers.

Finally, to close this exploratory stage, 20 interviews were also performed with Portuguese IEAs from different industrial sectors to obtain insights regarding the current support to the international activities of

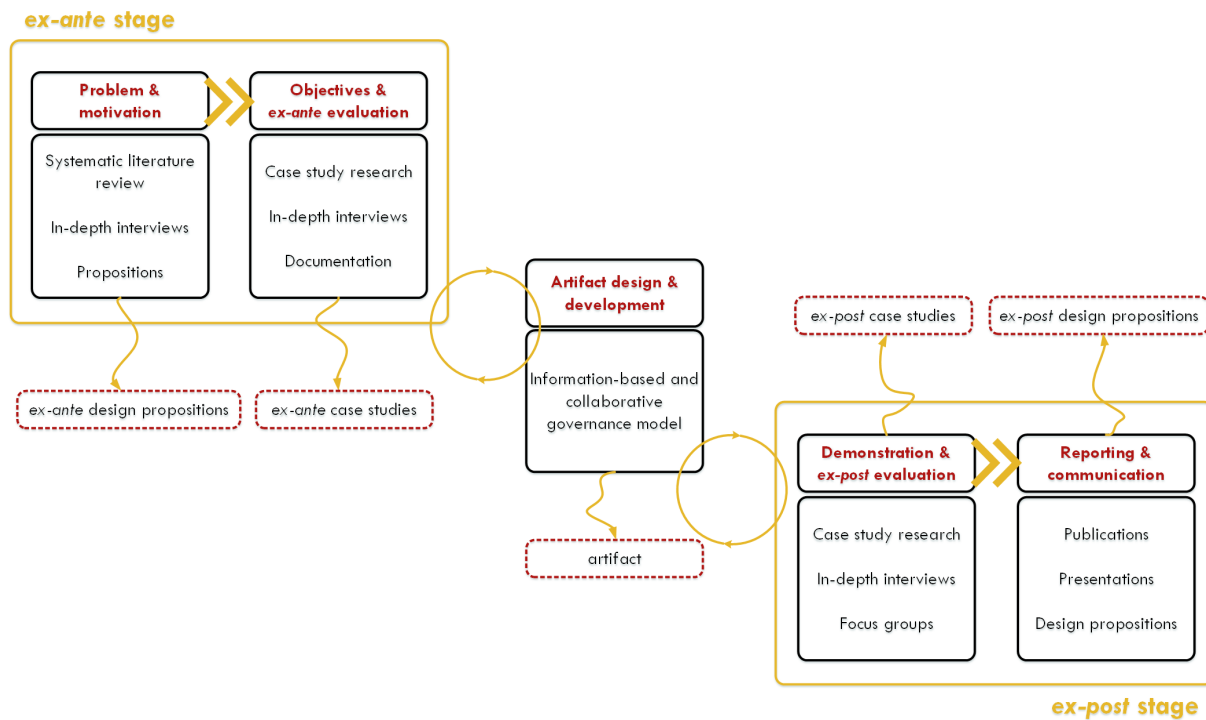


Figure 1: Research framework of this doctoral project

their associated SMEs. Other goals were: (i) to understand their future vision on the internationalisation of their associates; (ii) to identify information management needs and characterise collaboration types; and (iii) to identify information and communication technologies in use. The data is now under analysis to be discussed and published in the next few months. The next stages of research will be the design and development of the information-based and collaborative governance model (artifact), in parallel with more focused research using case studies. This will allow to iterate between the design and the evaluation of the artifact. For a better generalization of the findings, two Portuguese IEAs from two different types of industrial sectors will be studied and compared in the case studies: the IT and electronics industry that operates in a quite uncertain context; and the textile industry, where more certain and foreseen environments are expected. This will also allow to understand the differences and similarities regarding the problems and information needs of these two sectors. For validation purposes, the developed solution will be tested and presented to IEAs and SMEs from different industrial sectors and from different countries. For this purpose, focus groups will be performed, with modifications and improvements being made according to the feedback obtained.

3 The value to Society

This doctoral project can help to improve the internationalisation processes of SMEs. The project aims to show that IEAs can act in a more active way in supporting the international activities of their associated SMEs. One important development for the positive impact of IEAs on the internationalisation process is the evolution for a more collaborative network, fostering flows of information between associates. The information governance model to be developed will help to support this, by answering the questions: what information is needed, how to make use of it and who is responsible for it. Hence, the model can be further used by IEAs for the design and development of new methodologies and tools to support SME internationalisation. This study will also help SMEs to understand the functioning and the benefits of using the services and initiatives promoted by the IEAs to face their lack of resources to operate in international markets. With the support of information management practices and collaborative networks from the IEAs, SMEs will also be able to improve their international success and decision-making capacity to internationalise.

Regarding the contributions to the scientific knowledge, this project contributes to the IB area by considering IEAs as the research setting and as the institutional network support for the internationalisation of SMEs. This fills an existing gap and contributes for both the IB literature and the institutional network perspective of internationalisation. Moreover, this study contributes to the research of business associations, as there is not much evidence in this literature in what regards the influence of IEAs in international environments of firms. Finally, this research will also contribute to the IM area by exploring aspects regarding information organisation, information life-cycle, and informational behaviour of the decision-makers, as well as by providing: a detailed and systematic analysis of the information and collaboration requirements to support SMEs in internationalisation processes; and an information-based and collaborative governance model that foster knowledge sharing between SMEs aiming to improve their internationalisation processes.

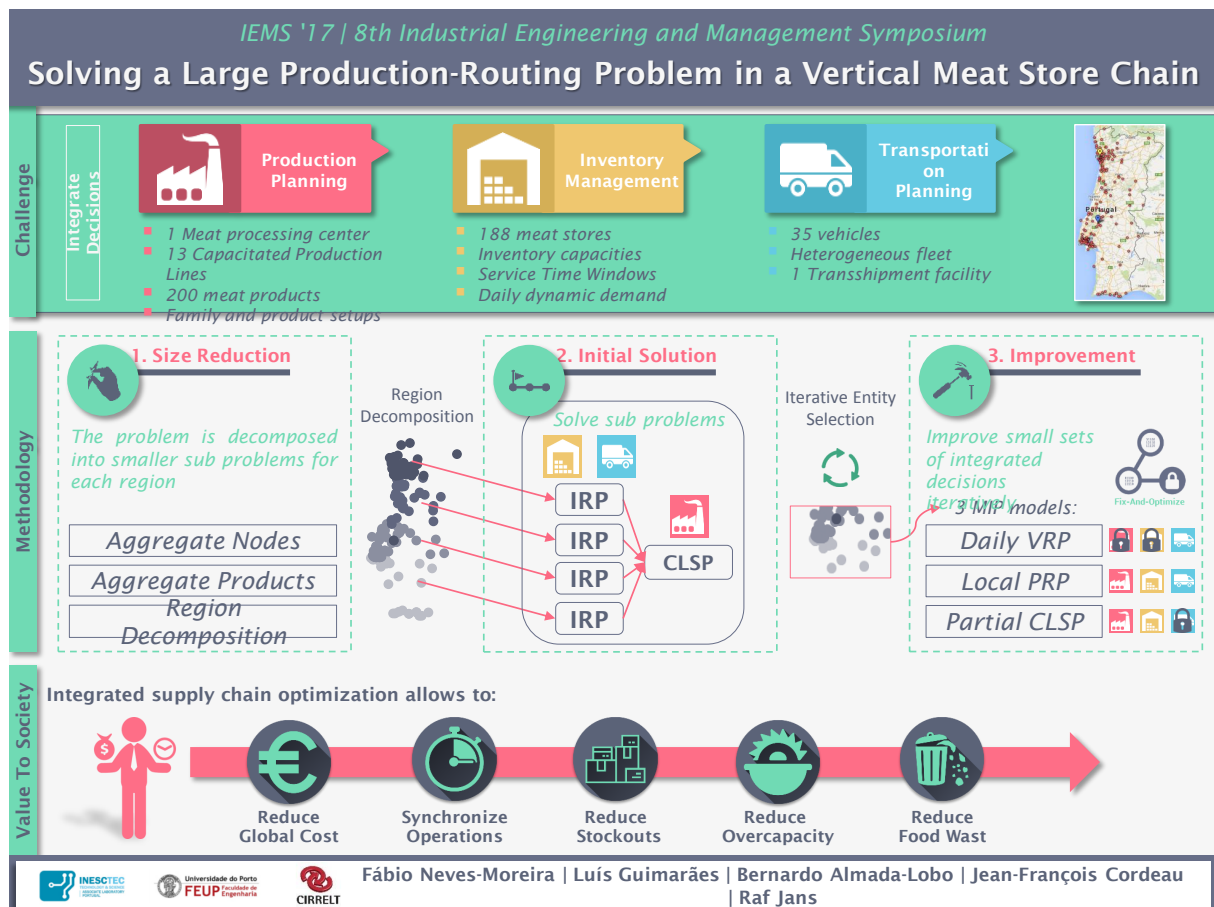
Acknowledgments

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Solving a Large Production-Routing Problem in a Vertical Meat Store Chain

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1 The Challenge

The problem addressed in this work is inspired by industrial contexts where Vendor Managed Inventory (VMI) policies are applied. The supply chain comprises a single meat processing centre with several production lines and a fleet of vehicles that is used to deliver different products to meat stores spread across the country. The operations and the product flow are presented in Figure 1. A considerable set of characteristics, such as product and family setups, perishable products, and delivery time windows, needs to be considered in order to obtain feasible integrated plans. However, the dimensions of the problem make it impossible to be solved exactly by current solution methods. Therefore, we propose a novel three-phase methodology to tackle large Production-Routing Problems (PRPs) combining realistic features for the first time. By applying adequate decomposition techniques to the PRP, we overcome the difficulties created by the size and complexity of the original problem. The computational results show

that our solution approach is competitive when compared to other approaches presented in the literature. Furthermore, as the size of the problem grows, our algorithm performs better, which is in-line with the main objective adopted during the design phase. Additionally, in less than an hour, the algorithm achieves superior quality solutions compared to the current decoupled production-routing plans used by the meat store chain which inspired this research.

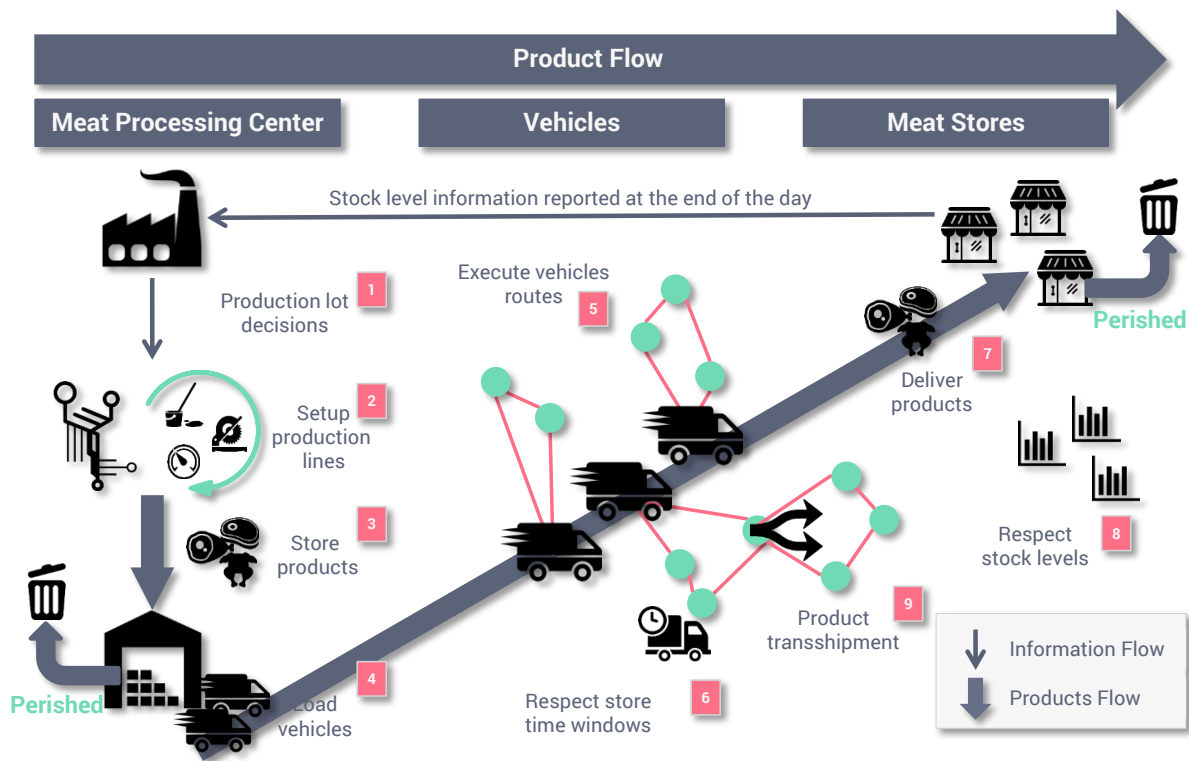


Figure 1: Schematic representation of the real-world challenge

2 The Methodology

To tackle large instances of this complex problem, we propose a novel methodology comprising three phases (see Figure 2). The first phase attempts to reduce the problem size by focusing on three dimensions: similar products with low demand are aggregated, in order to reduce the number of considered products; stores are clustered based on their geographic location and service times, so as to consider a smaller number of nodes; the problem is decomposed into regions with an associated reduced set of potential vehicle routes per region, reducing the complexity of the routing part.

In the second phase, an Inventory-Routing Problem (IRP) based on the aggregated data defines the delivery schedule and the quantities to be supplied to each store in each decomposed region. A Capacitated Lot-Sizing Problem (CLSP) is then solved to define the production setups and quantities for each production line. The initial solution is thus built in a distribute first-produce second fashion.

In the third phase, a Fix-&-Optimize based meta-heuristic improves the initial solution, jointly optimizing production, inventory and routing decisions. In each iteration of the meta-heuristic, the incumbent solution is analysed and a subproblem is defined containing a subset of entities that are present in the original problem. Depending on a selected neighbourhood, based in one of three proposed Mixed-Integer Problem (MIP) formulations, the algorithm focuses on improving smaller sets of decisions at a time. For instance, we may improve only the routing part by creating a subproblem with some vehicles on a given period or we can try to optimize integrated production and inventory management decisions by selecting some production lines and retail sites. In each iteration, the algorithm adapts the size of each subproblem. If the previous subproblems were solved in short computational times, the algorithm

is allowed to choose a larger number of entities to be optimized in the next iteration. This procedure ensures that we are able to optimize larger subproblems, considering a broader view of the original problem, without compromising running times. When a maximum number of non-improving iterations is performed, the algorithm advances to another neighbourhood to explore different types of integrated decisions. The procedure is repeated until the stopping criteria are met.

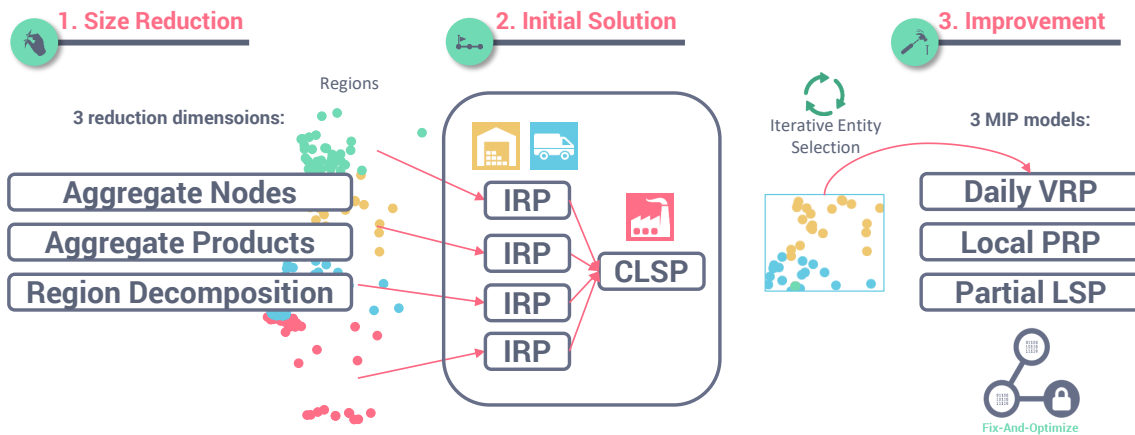


Figure 2: Solution approach fluxogram depicting the three phases.

3 The value to Society

The integration of different planning problems is the next step in order to achieve larger gains using operations research. Indeed, when a company decides to integrate its planning processes, alone or co-operatively, there is not only a direct benefit for the company itself but also plenty of indirect benefits that are absorbed by the surrounding entities. Particularly with the PRP, companies are able to reduce production, inventory and transportation costs while increasing their service level. From the perspective of the consumer, products are available at the right quantity and at the right time, meaning that several sources of waste are largely reduced as resources are allocated more rationally.

The models developed in this work can be applied to a wide variety of process industries such as oil products, food, electrical components, vending machines, and apparel. Regarding our methodology, by reducing the size of the problems, we allow for the possibility of solving larger and more complex problems, maintaining the objective of obtaining good quality solutions, applicable to the real-world. Note that this is true not only for the PRP but also for other general optimization problems of large dimension.

A Benders Decomposition Approach to the Berth Allocation Problem

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The Berth Allocation Problem

To berth or not to berth?



- When?
- Where?
- Has the vessel arrived yet?
- Will the vessel be delayed?
- How long will it last?
- How much will it cost?

Flávia Barbosa, José Fernando Oliveira, Maria Antónia Carravilla

1 The Challenge

The increasing demand for ship transportation is a major problem faced by marine terminals around the world. A great amount of vessels arrive over time and the terminal operator needs to assign them to berths to be serviced while minimizing the operational costs. Building new facilities, adapting existing ones to receive new vessels and accommodating a wider variety of types of vessels does not always guarantee that the service will be efficient.

Many ports around the world have been subject of study. In Japan's ports charges have been higher than those in other major hubs over several years. Part of the increased cost is the result of overcapitalization of the port for the relatively small cargo volume. The Medcenter Container Terminal, located in the port of Gioia Tauro is linked to nearly 50 spoke ports and is geared towards transshipment activities involving mother vessels and feeders operating in hub-and-spoke system.

With the competition between seaports, especially among those geographically close to each other, a greater difficulty in managing vessels and a search for a decision support to accommodate the massive flow of ships and containers in ports came up, making it interesting to investigate the Berth Allocation Problem (BAP).

Berths are the most important resource and a good allocation entails an improvement in customer satisfaction and an increase in revenue for the port. It is very expensive to the vessel to remain waiting in the mooring position and cranes are certainly not a cost-effective investment. It is important that as many cranes are used as needed, maximizing the number of containers loaded or discharged per unit time and consequently maximizing the the efficiency of operations.

Due to the large volume of containers to be traded and the large number of vessels to be serviced, the operators in charge of handling the load may not guarantee cost savings with higher productivity. The challenge of handling vessels with very high capacity must be overcome by key factors that provide efficiency for stacking and transportation of this large amount of cargo. High productivity containers at low cost is essential to the operation of the terminal. Efficient programming can contribute to a successful operation, improving customer satisfaction, increasing load flow, and leading to higher revenue from the port.

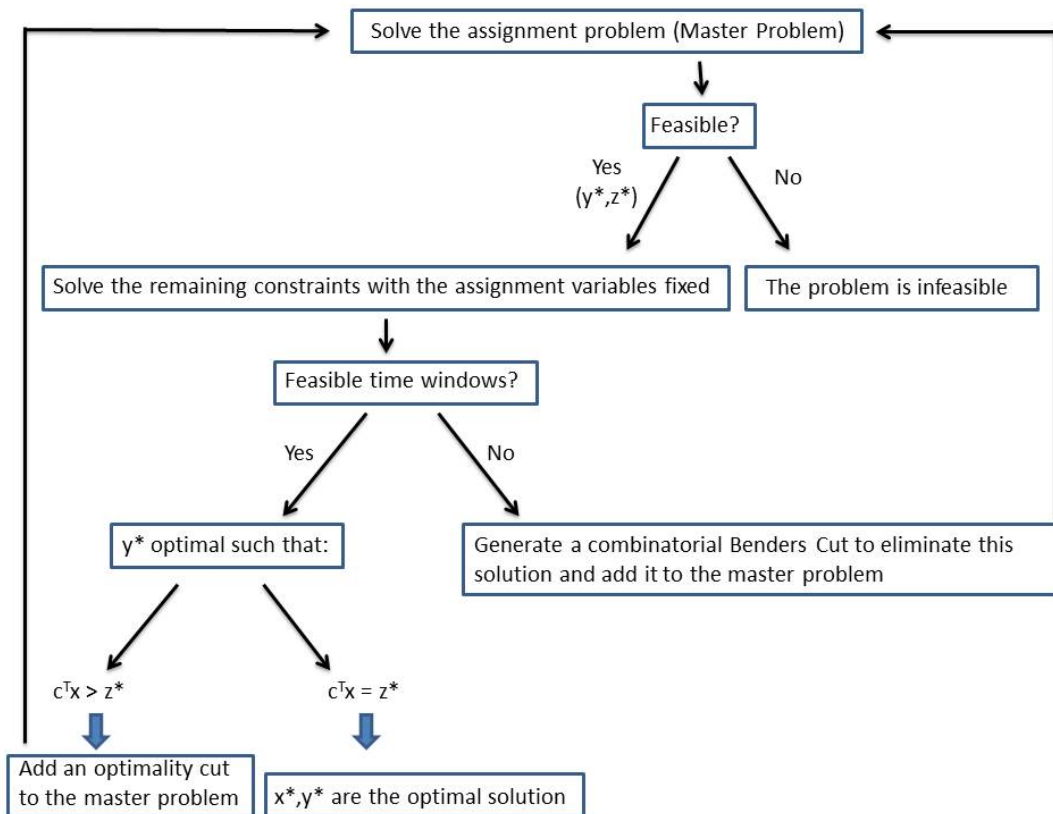


Figure 1: Decomposition scheme

In this way, given a set of vessels with arrival times, expected departure times from the port and processing times and a set of berths with availability time windows, the BAP is modeled as a heterogeneous vehicle routing problem with time windows and its main goal lies in determining in which berth each vessel must be moored, the precedence relationship between the vessels at the same berth and the time each vessel starts being serviced, minimizing the weighted sum of vessel service times.

2 The Methodology

The computational complexity of the BAP lies on the dynamic arrival of vessels. The problem is NP-hard because vessels have a release date and they are not allowed to berth before the expected arrival time.

A decomposition approach is proposed to tackle this problem. Benders Decomposition is a technique often used to solve certain classes of difficult mixed-integer linear programming problems. First, an assignment problem is solved (called the Benders Master Problem), without taking into account the time windows of vessels and berths. This assignment variables are considered the “complicating variables”, and once they have their value fixed, the problem is reduced to an ordinary linear problem. Then, we check if this solution is feasible for the time windows constraints. If it is feasible, we add an optimality cut and solve the master problem again. If it is infeasible, we generate Combinatorial Benders Cuts in order to eliminate this solution and the Benders Master Problem is solved again. These Combinatorial Benders Cuts have shown in literature to be very effective when solving mixed integer programs involving logical implications modeled through “big-M” coefficients, as it occurs with the time windows constraints.

We will try to solve this problem for scenarios with 25 and 35 vessels and 5,7 and 10 berths and we consider deterministic data: the expected arrival and processing times are known previously.

3 The value to Society

If an unexpected problem comes up at the terminal, as changes in arrival times of some vessel or in the amount cargo to be (un)loaded, the operator must be ready to change the service system as soon as possible ensuring efficiency without incurring extra high costs. Developing a tool that reoptimizes the system on the fly and quickly find a solution to the problem can help improve the dynamics of the terminals and consequently its revenue. In fact, arrival dates are just estimates, as external factors (adverse sea conditions due to bad weather) and internal factors (equipment breakdown, for example) hinder the fulfillment of the initially planned dates and times.

Institutional networks in the development of regional technological capabilities

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IEMS'17

The Challenge

- The aircraft manufacturing industry is one of the rapidest growing market
 - USD 16.87 Billion (2016) → USD 29.16 Billion (2021)
 - Compounded Annual Growth Rate(CAGR) : 11.57%
- It has critical influence in socioeconomic development and skilled employment

The Methodology

- Contextual data on the Portuguese aircraft industry will be collected and analyzed through interviews and surveys
- Quantitative analysis regarding products and technology will be complemented

The Value to Society

- This research aims to discuss strategies for companies to become competitive players against existing leading companies in the aeronautic industry
- This research would be helpful to understand and assess the potential impact of these strategies, such as differences in technological capability in the sector

1 The Challenge

Demand for new civilian aircrafts is expected to grow in the coming decades. Boeing's Current Market Outlook 2015-2034 shows that the world will see demand for 38,050 new jet aircraft from 2015-2034 at a value of \$5.6 trillion. In addition, according to 2014 Global Aerospace and Defense Industry outlook by Deloitte and the Global Market Forecast 2016-2035 by Airbus, it is expected that the next 20 years will see a dramatic increase in commercial aircraft production.

These forecasts for continuing and perhaps growing demand of commercial aircrafts are driven mainly by replacing obsolete aircrafts by fuel-efficient aircrafts and increasing demand in passenger travel, especially in the Middle East and the Asia Pacific regions. In addition, the aeronautic industry is a high-value added sector on which many governments focus to foster national involvement and growth because of its

potential for socioeconomic development and its critical influence in skilled employment. Therefore, not only countries and regions very active in the industry with their major manufacturers of civil transport aircraft such as the U.S., EU, Brazil and Canada, but also countries relatively new to the industry such as China, Japan, Mexico and Malaysia try to develop their own capability and enter the sector's global value network. Hence, this context represents an opportunity for researchers to analyze the market challenges and opportunities and to provide a framework for countries to increase their participation in an industrial global value network.

2 The Methodology

The work will focus on strategies with high potential for Portugal to play a more effective and competitive role in the aeronautic sector. The research will start from a specific aeronautic segment, namely, aircraft interiors. The preliminary research process starts with a study on the certification process of aircraft interior parts. Additionally, it will delve into collecting and describing contextual data on the Portuguese aeronautic industry to understand its relative economic and technological competitiveness. A search of the relevant literature will be done to comprehend their present position and challenges in the global and regional value network of interior components. This will be complemented with data from a questionnaire to be sent to existing and potential Portuguese companies in the aeronautic sector about their products and technologies. Leveraging these initial analyses, the impact on the proposed strategies will be analyzed. The effect of the strategies on the side of economic growth and technological capabilities in the region will be assessed both quantitatively and qualitatively.

3 The value to Society

The Portuguese aerospace industry is set on increasingly integrated and complex technological capability primarily driven by the government. A recent successful investment has attracted one of the global players in the sector - Embraer, a Brazilian company. Many efforts were directed towards stimulating collaborative work, creation of new technology-based players and training of the work force. Nevertheless, the sector in Portugal has not had impressive attainments.

The objective of the present research is to provide a framework to understand the sector's global value chain, focusing on its barriers, challenges and opportunities. In addition, this research aims to discuss strategies put forward by governments, institutions, and companies to become competitive players against existing leading companies in the aeronautic industry. The case of the Portuguese aeronautic industry will be used to develop an analytical framework, in order to discuss possible strategies for the industry leading to technical and economic advances in the country. Additionally, this research seeks to understand and assess the potential impact of these strategies, such as differences in supply chain and technological capability in the sector.

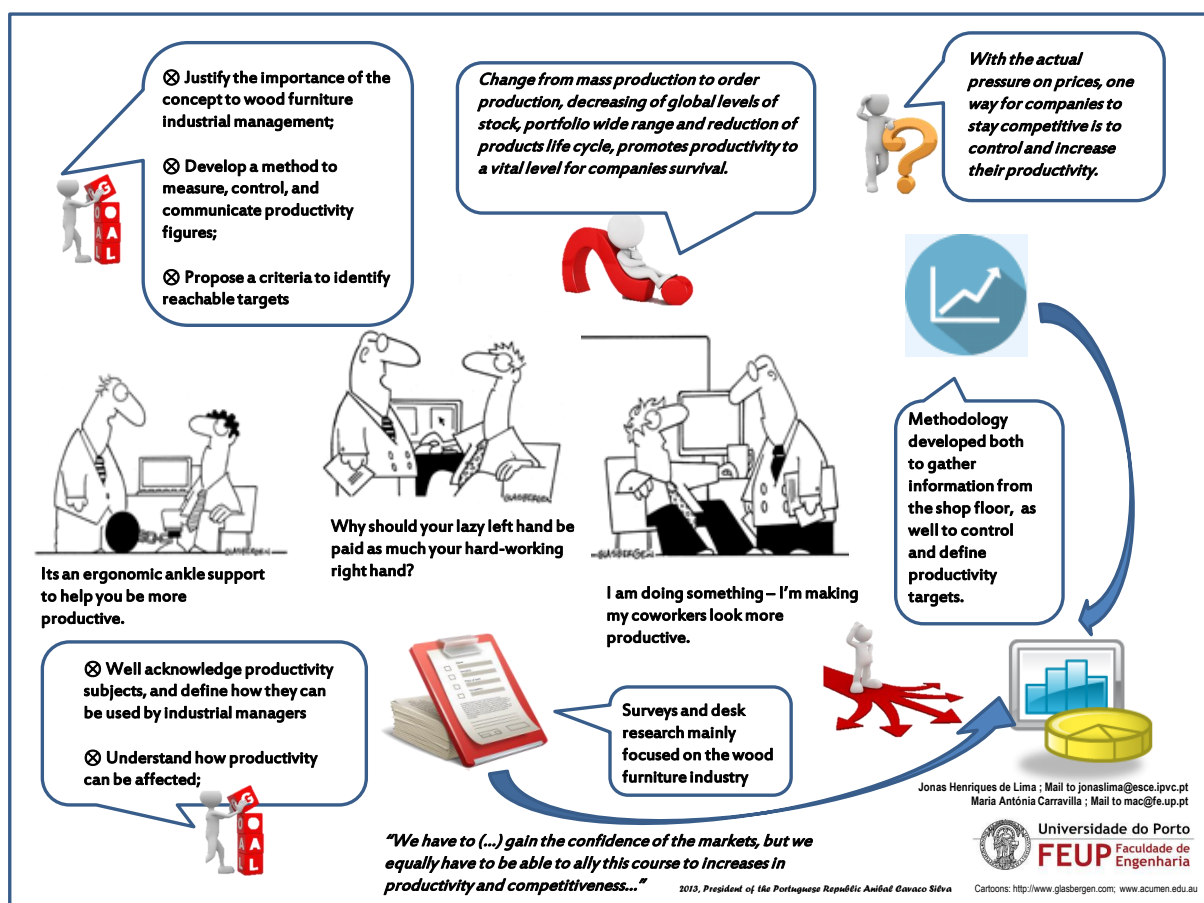
Aknowledgement

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The Impact of Productivity on Modern Industrial Management: an applied analysis of the Portuguese wood furniture industry

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1 The Challenge

Nowadays the word "productivity" is used very often. Portuguese company managers usually relate the lack of competitiveness with it; politicians "elect" it as a flag and keyword in their speeches about social union; entrepreneurs identify it as one of the criteria do be used to define internal goals; workers use it on their daily chats. So, the importance of productivity can be analyzed at various levels:

- **National level** – as a key element to progress and economical growth;

- **Industrial level** – considering that a productivity growth above average leads to relative decreases in cost (and price), and therefore strengthens the competitiveness of a certain industrial sector;
- **Company** – fundamental towards profitability and the survival of a company;
- **Individuals** – contributes to the fulfillment and well-being of each worker.

There are however still several important questions to be answered, namely: Are the fundamentals of productivity well understood by all relevant parties (that is, shop floor workers and managers)? Is it possible to clearly understand what affects productivity? Is it possible to measure productivity using accurate but easy to understand and well accepted indicators? What is the importance of productivity in the enhancement of some traditional Portuguese industries (specially the wood furniture Industry)?

This research will find answers to these questions, focused on the Portuguese wood furniture industry, allowing to:

1. Well acknowledge productivity subjects, and define how they can be used by industrial managers;
2. Understand how productivity can be affected;
3. Justify the importance of the concept of productivity to industrial management;
4. Propose a method to measure, control, and communicate productivity figures;
5. Propose a criterion to identify reachable targets for each productive unit of a certain company.

2 The Methodology

One of the goals of this research is to clarify the impact of productivity on industrial management. To do so, we focus our analysis on the Portuguese wood furniture industry (classic, modern style, and components production), collecting data from from the main players in each company.

The Portuguese wood furniture industry was chosen as a case study because it has four characteristics that, together, lead this industry to a position where productivity can make the difference:

- Massive dependence on human labor;
- Relevance in the national industry;
- Substantial levels of automation;
- Players presenting different export levels.

These four characteristics imply a preponderant disposition and sensitivity towards productivity subjects.

The data are collected both at the management and at the operational level through surveys. After the productivity and efficiency concepts are well understood, this study will select the most adequate method (among several possible ones) to define productivity targets, benchmarks, and growth potential.

The surveys and interviews will be used to involve all the workers that might affect or be affected by productivity subject, and listen to the main parties' point of view about productivity, valuing their opinion about the topic. The involvement of the workers will also be useful to validate some assumptions and conclusions from the bibliographic revision, as well as to get some clues about the more effective way to control and increase their productivity. Therefore, a pilot test will be implemented on selected work stations of one of the companies where the data collection, the defining of targets and communication methods (like dashboards) are to be implemented.

3 The value to Society

In general, the adoption of the productivity concepts on daily industrial management practices faces two big obstacles. First, due to several misunderstandings, productivity concepts are often viewed as a threat by each individual worker (for some people, productivity increase means an increase in exploitation). On the other hand, in some cases it might be an “invisible” concept to most people, and therefore hard to control. Given so, this research intends to help getting through these obstacles and simultaneously to highlight the benefits of using these ideas of productivity and efficiency to increase the competitiveness of a certain industrial activity.

Nevertheless, a fundamental step in order to use productivity as a management tool, is to measure it. For that to be possible, it is necessary to understand it and conceptualize a system that has the ability to both measure and control productivity. This productivity measurement and control system is expected to be simple, fair and transparent, allowing the following:

Continuous Improvement monitoring the productivity performance of a certain productive unit will allow to register any fluctuation that occurs, generating base data for a further research on its causes.

Planning the analyses of productivity evolution, will allow a better projection on the amount of resources needed for the targets that were set, as well as to forecast any corrective measures needed due to trends or performance deviations.

Benchmarking productivity data of one or more units enables a comparison with other identical units, both at internal and external level, identifying improvement potentials, threats, weaknesses, and strengths.

Incentive Systems give companies the possibility to add to the workers' wages, a reward share related to productivity performance

Summarizing, one of the main goals of this work is to clarify what productivity theories and concepts might be used on this specific industry, highlighting their increasing importance within modern engineering and industrial management. The ambition is to develop a management tool that may not only control productivity but motivate employees and positively influence the way resources are used.

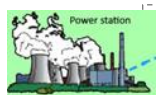
A Service Perspective to Customer Engagement with Smart Grids: Co-Creating Value with Smart Energy Services

Luísa Gonçalves*[†], Lia Patrício*

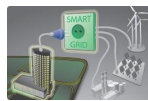
**Faculdade de Engenharia da Universidade do Porto*, [†]*INESC TEC*

A SERVICE PERSPECTIVE TO CUSTOMER ENGAGEMENT WITH SMART GRIDS: CO-CREATING VALUE WITH SMART ENERGY SERVICES

The Challenge



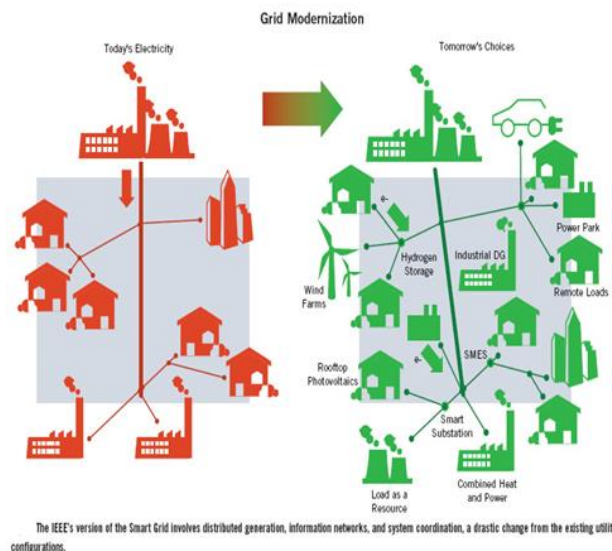
To limit global warming, greenhouse gas emissions (fossil fuels energy sources) must decrease.



The study aims to respond to these challenges by analyzing the customer engagement with Smart Grids from the service logic perspective.



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The Methodology

- Qualitative and Quantitative methods to access customers;
- Service Research approach to integrate the analysis of customer engagement in the process of value co-creation.

The Value to Society

This change in paradigm stimulates service providers and customers to act together, in order to establish robust relationships, encouraging technologies and strategies that optimize the entire energy system.

1 The Challenge

According to the IEA report (International Energy Agency), the global demand for energy is expected to keep rising over the next three decades. As the demand increases, more fossil fuels are required to generate energy. The massive use of fossil fuels increases the greenhouse gas emissions (GHG), which result in global warming.

To address this issue, the Paris Agreement (COP21), signed by 195 countries in 2015, set out an action plan to limit global warming below two degrees Celsius (European Commission - Climate Action). To this end, solutions must be implemented to reduce emissions (GHG), while maintaining global economy on the growth track.

These solutions require considerable changes in the traditional power system to intensify the use of renewable energy. In this context, the smart grids technology presents the key elements to achieve these goals.

Smart Grids is an electricity network that uses communication technologies to monitor and manage the transport of electricity. The sensors installed along the grid enable operators to visualize and manage, in real time, all generation sources, distribution systems, and final consumer consumption. In practical terms, this new perspective enables, for example, the massive use of renewable sources located at different points of the grid. Operators and utilities can choose the best option to fulfill the demand according to the geographical location, load balance requirements, etc. Moreover, the final consumer can also manage and monitor consumption of his/her own house or facilities. This technology maximizes the system reliability since decisions regarding load balance and stability can be taken in real time, that consequently minimize costs for the final consumers by coordinating the resources of energy according to each context.

The use of communication systems and sensors to control and manage consumption, objects, etc. is not exclusive to the energy sector. This structure represents the roots of smart technologies (Internet of Things) that will replace various systems until the end of this decade.

Smart Grids are changing the paradigm of energy production and consumption, by enabling customer empowerment and participation in more active home energy management and consumption, with significant impacts on effectiveness because this new technology unlocks new ways of generating, distributing and consuming energy that changes the sector as a whole. Also on efficiency, due to the increase in the grid reliability, stability, and control.

In the traditional energy sector, the customer plays a passive role towards energy consumption, presenting low levels of interaction with service providers. In contrast, in the smart grids technology, these customers are the central pillar of the system and all actions are addressed to fulfill their needs. Smart Grids customers play active roles due to the interactions (with system, devices, providers, etc.) required to manage, control and visualize the consumption, and change behavior to get benefits.

In this context, customer engagement represents a key enabler to smart grids implementation. However, engaging customers in this new perspective of energy consumption is considered quite challenging for two reasons. Firstly, customers are not motivated to change behavior (passive nature) and attitudes towards energy consumption and service providers, whose relationships have been the same for more than a century. Secondly, service providers still do not have a concise and coherent understanding regarding the relation between customer engagement and energy consumption behavior.

The objective of this study is to respond to these challenges by analyzing the customer engagement with Smart Grids from the perspective of service logic. In Service Research, the analysis of customer engagement from the service perspective requires the analysis of the value creation and co-creation in the context of smart energy services, because only engaged customers can value and interact with service providers. It implies to analyze how energy customers can integrate multiple resources such as utilities, domotics, home appliances, and smart devices to co-create value. For example, instead of creating isolated incentives, as such pricing, energy providers should develop services that fit into customer value co-creation activities, focusing on interactions with multiple actors (providers, applications, devices and other customers) to co-create value. This value is co-created according to customer perceptions, experiences, and attitudes towards energy consumption.

2 The Methodology

The research method integrates the constructive perspective of Service Research to analyze the customer engagement with smart grid services. The study integrates literature on smart grids, the service-dominant logic, and customer engagement to propose a new perspective on smart energy services by considering customer engagement as a central element for value co-creation. The service-dominant logic perspective analyzes the relationships with different resource integrators involved in the service network, considering that customers are always value co-creators, and firms cannot create value but rather co-create it with their customers.

The design on how to approach the problem is in initial steps, however, the methodological approach of the research project will be built upon qualitative and quantitative methods to access customers through interviews and surveys. The aim is to raise the contextual, cognitive, behavioral and emotional aspects of customer engagement, which will lead people to adopt and co-create value in the smart energy era. This approach will enable to identify the drivers (antecedents, barriers, and consequences) of the customer engagement with smart energy services.

Previous smart grid research has studied how to change consumer behavior by engaging customers through financial incentives, but the results have been mixed. In this sense, a service perspective can bring novel contributions to understand and foster customer engagement with smart grids, as it views the customers as active co-creators of value, and the service as an enabler of value co-creation, together with other resources in the customer value network. The focus, therefore, moves beyond trying to change customer behavior through direct incentives, such as pricing, to understanding how smart energy services can engage customers by enabling new forms of value co-creation.

3 The value to Society

Despite progress in smart grids implementation projects, the customer behavior and attitudes in a smart context of energy remain largely unexplored. In the last five years, interest in the final customer of energy has been growing due to the imposition of understanding the reasons they tend to reject this new technology, which brings benefits for the planet's ecosystems and for society in general. In this context, a study that involves the analysis of the customer engagement with smart grids from the service logic perspective can unlock a successful transition in consumption behavior from a passive role to an active and central role of the smart energy services. This change in paradigm stimulates service providers and customers to act together, in order to establish robust relationships, encouraging technologies and strategies that optimize the entire energy system (business models, operation management, etc.), rather than only the individual parts.

Although the energy market is categorized in the service sector, the perspective of service logic (resource integration, value co-creation, and customer engagement) has not been explored in an integrated ways. The analysis of different research areas reveals relevant contributions that can bring important insights to move beyond isolated incentives to customer engagement with smart grids, to developing integrated service offerings that engage the customer by enabling them to co-create value in various ways.

Finally, the smart grid technology carries the solution for the environmental impacts caused by the greenhouse emissions because it enlarges the capacity of using renewable sources. This technology is focused on the final customer that has the capacity to manage and monitor the energy consumption, playing an active role in the relationships with multiple actors involved in the service network (providers, operators, utilities, etc.). However, customers tend to reject this new technology because the service provision of energy has been the same for more than a century. The fostering of customer engagement lead them not only to change the consumption behaviors but also co-create value with service providers, unlocking the offering of new smart energy services and new business models.

Acknowledgements

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Service Design through multidisciplinary lenses

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Service Design through multidisciplinary lenses

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- **Challenge:** This article identifies and systematizes multidisciplinary contributions to Service Design, in order to give theoretical ground to advance Service Design as an interdisciplinarity field.
- **Methodology:** Grounded theory (Charmaz 2006)*.
- **Value:** This article identifies and describes Service Design multidisciplinary perspectives, facilitating Service Design team work, by clarifying purposes of the different disciplines' contributions to the field.

* Charmaz, K. (2006) Constructing grounded theory: A practical guide through qualitative analysis (Introducing Qualitative Methods Series). Sage Publications Ltd.



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1 The Challenge

This article identifies and systematizes multidisciplinary contributions to Service Design, in order to give theoretical ground to advance Service Design as an interdisciplinarity field.

2 The Methodology

A Grounded Theory (GT) approach was adopted, involving a two-step qualitative study with Service Design experts from multiple fields. In the first stage, the multidisciplinary research team established a selection of papers in order to identify different fields that contribute to Service Design. The second stage involved an extended literature review, based on the recommendations of 13 world leading researchers on

Service Design that covered the identified fields. These articles were analyzed following the three types of GT coding - open, axial and selective - on Nvivo.

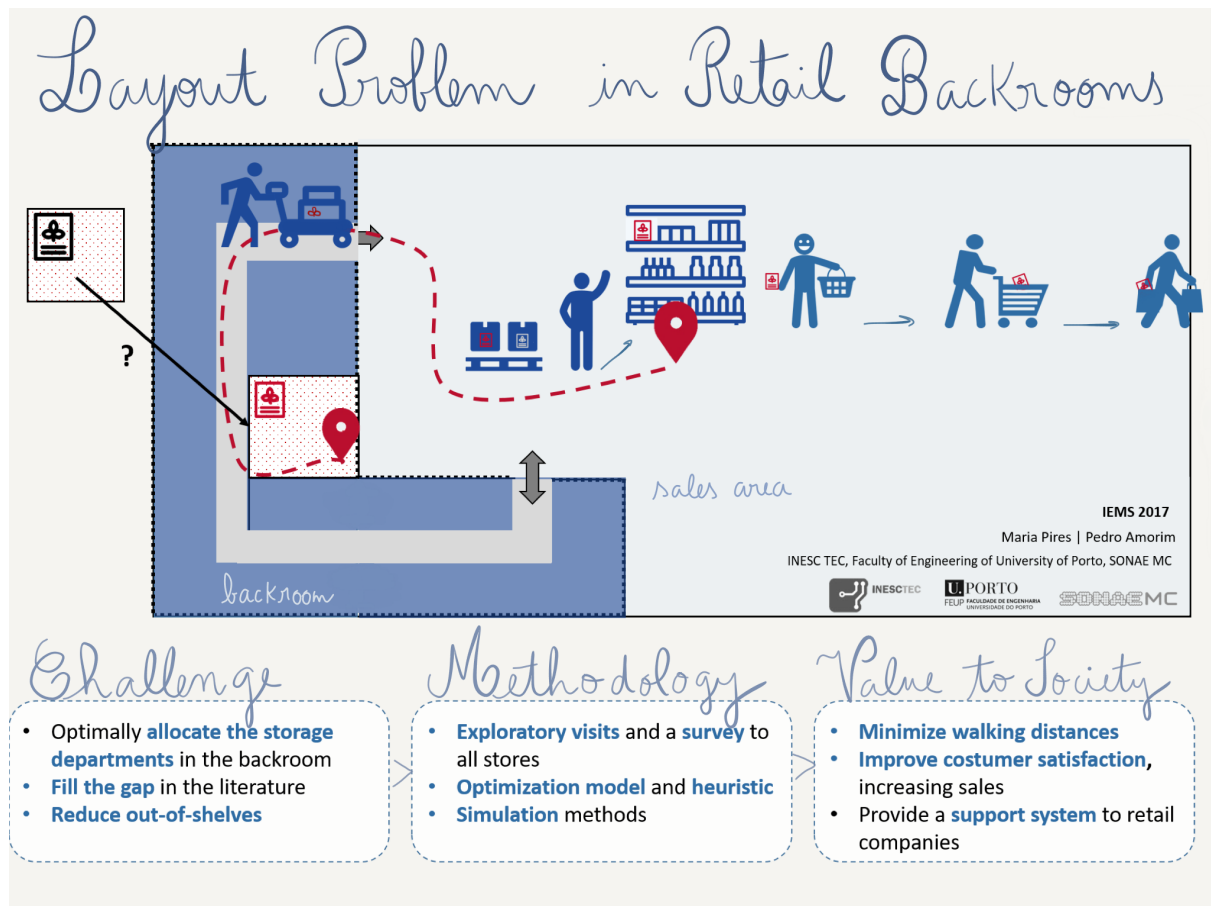
3 The value to Society

Six perspectives were identified as contributing to Service Design: Design, Service Research, Interaction design, Marketing, Operations Management and Information Systems. The perspective of each field is described, in terms of goals, objects, processes and outputs. Following Service Research priorities, this article identifies and describes Service Design multidisciplinary perspectives, creating theoretical basis to advance Service Design as an interdisciplinary field. Moreover, this article facilitates Service Design team work, by systematizing multidisciplinary contributions connected to the field and clarifying purposes of the different disciplines' contributions to Service Design. Besides, it helps practitioners to know what competences they can use from the different perspectives when developing Service Design projects.

The layout problem in grocery retail backrooms

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1 The Challenge

The ongoing transformation of retail is impacting every aspect of its operations, requiring ever greater operational efficiencies, 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, making this area indispensable. 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 is the space that creates direct value to the store. In contrast to the selling area, the remaining space is dedicated to the backroom storage, whose design is often neglected. Nonetheless, the appropriate design of the backroom is crucial due to its impact on store performance and, ultimately, on client satisfaction and store sales. In this presentation we will focus on the backroom layout problem that consists in the optimal allocation of the storage departments within the confined and irregular backroom space in order to minimize in-store walking distances and improve operations efficiency.

The backroom layout problem has 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 efficiencies and design, much less the knowledge on how to perform it.

Currently, in practice, the design of the backroom areas is mainly established on the perception of the architect that is based on similar stores, when instead it should be carefully studied, considering in-store logistics and operations, expected orders' volume of the regular activity as well as seasonal and promotional activity. To better tackle these situations, designers should also rely on formal means to assist the design process, rather than follow ad-hoc procedures. Nonetheless, the literature on this topic is very scarce. There exist some studies regarding the best suited design for the sales area. However, none of them tackles the backroom areas. With this research, we aim to fill this gap and propose a model to define the layout for grocery retail backrooms as well as to test it in a case study company.

2 The Methodology

In order to tackle this problem a three-step approach has been followed.

Firstly, a thorough literature review on the subject of layout modelling was conducted. Since the literature on the backroom layout problem is very scarce (inexistent), literature on related planning problems was reviewed, namely the warehouse/facility layout problem and the two-dimensional bin packing problem. This allowed an understanding of the gap in the literature regarding the allocation of departments on irregular spaces/shapes. Nevertheless, the concepts used in these problems can be extrapolated to the backroom layout problem.

In parallel with the literature review, we performed an exploratory work where visits to retail stores of a Portuguese retail company were performed as well as non-structured interviews with the architects responsible for this task in the company. This allowed firstly to notice operational in-store problems and inefficiencies regarding backroom layouts as well as to map the process currently used to define store layouts, which is mainly established on existing stores and on the perception of the architect.

Secondly, an optimization model for the backroom layout problem, illustrated in Figure 1, was developed. The goal is to minimize the walking distances between the backroom and the sales area which influences the in-store logistics, such as the shelf refilling process, and, ultimately, customer service level. The model considers the layout in the sales area, the backroom physical constraints as well as the products' flow within a store. The solution methodology is divided in two sequential phases. The first is the pre-processing phase and aims to discriminate the possible backroom department formats, assuming always rectangular shapes and no rotation. The second phase is the optimization model, which aims at allocating the departments in the backroom space. Nevertheless, the model has shown inefficient performance when solving more complex problem settings. Therefore, the third step consists in developing a genetic algorithm contemplating various configuration options to find a time-saving close to the optimal approach.

As future work we plan to develop a heuristic model able to incorporate the backroom layout particularities, such as low and irregular shapes, the layout of the sales area, the I/O points (e.g., unloading docks and doors) and the adjacencies between departments (e.g., departments that should be placed together).

Finally, to evaluate the overall backroom layout, we plan to employ simulation methods and assess key performance indicators such as in-store walking distances. The validation phase will consist on the application of this model to design the backroom layouts of an international retailer. We also plan

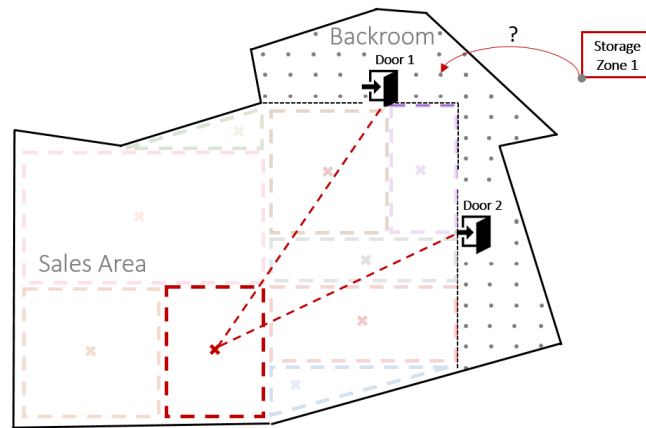


Figure 1: Representation of the backroom layout problem.

to compare the results obtained with the layouts currently practised in stores. Furthermore, we have conducted a survey that was sent to store managers where they were asked for their opinion on the backroom layout. In this way, we are able to confirm that the layout suggested by the model is meeting the real needs of stores.

3 The Value to Society

The first contribution concerns 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.

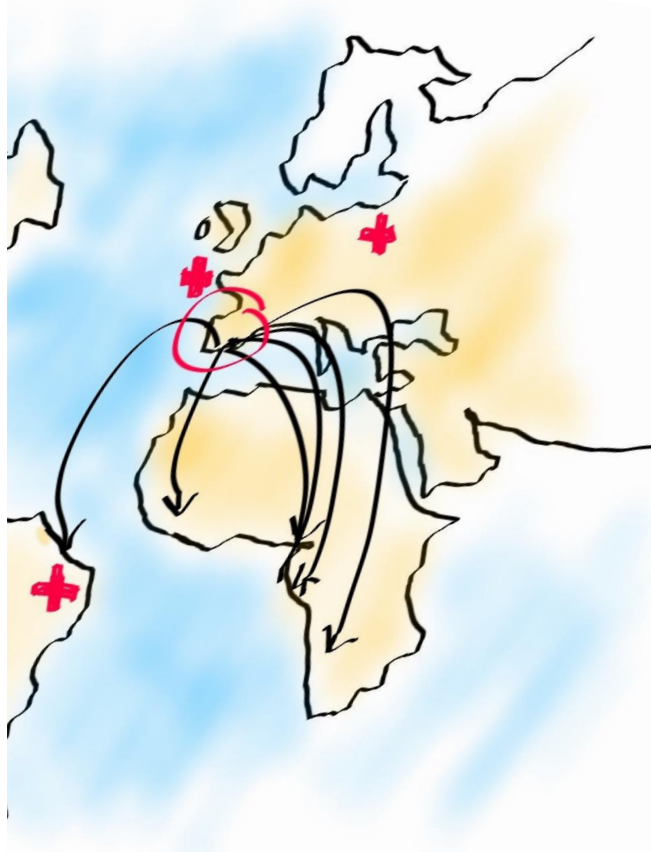
From a practical point of view, we expect to achieve cost savings in the construction, storage and material handling of backrooms. Moreover, it is also our purpose to guide retailers in defining their backroom areas in a standardized and efficient manner.

Finally, 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 remodeling processes. Therefore, this academic research is being applied to real problems and bringing actual benefits to the grocery retail industry.

Physician emigration: should they stay or should they go? A policy analysis

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Physician emigration Should they stay or should they go? A policy analysis

METHODS

An agent-based model
Migration decision-making
Migration market
Health labour market

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Sofia C. Gomes
Álvaro Almeida
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1 The Challenge

An adequate medical workforce is a critical requirement to a healthy population, as the delivery of health care services is still highly dependent on physicians. In general, health authorities are aware of the consequences of a disproportion in the physician workforce, and put this issue on top of their political agendas. Notwithstanding, shortages of physicians or a geographical maldistribution of health human resources are still very common and affect all countries alike, from low- to high-income countries, suggesting that despite the rhetoric no public policies have been enacted to address this issue or such policies have been ineffective.

Several factors originating from both the demand- and the supply-side may cause an imbalance in the medical workforce. Institutional and regulatory barriers, such as *numerus clausus*, licenses to practice

or mandatory retirement age; service delivery arrangements that may condition both the skill mix and the productivity of the health care workforce; non-controllable factors, such as mortality; changes to demography, in particular to the size or age structure of the population; migration flows; epidemiological needs; and many other factors may cause a change in the medical workforce. Of all these factors, emigration is a critical one, as it produces an immediate influence on the supply of physicians.

Physicians are no different from other people, and emigrate with the purpose of being better off (ex ante). The international migration literature lists a significant number of “push” and “pull” factors that may act as stimuli to leave or attract one to other countries, respectively. In the particular case of human resources for health, several authors have identified critical factors, for instance: inadequate compensation, when compared to other sectoral wages, but also to wages in other countries; remuneration system not related to performance; heavy workloads; poor working conditions; political instability; or unmet demand for medical education due to *numerus clausus* or lack of residency positions are reasons frequently provided for wishing to move abroad. Regardless of the working and living conditions in the home country, foreign countries may also offer fringe benefits that may attract physicians. For instance, training opportunities; better compensation, in terms of wage differential; active recruitment; or higher demand for health professionals.

The problem is well identified, but we still lack a policy analysis framework to help us answer critical questions, in particular those concerning physician emigration. When, if ever, should policy-makers intervene and promote retention policies? What are the benefits and the costs for the physician workforce, but also for the remaining population? Is it socially optimal to retain these physicians, or can emigration be a force for good in the health labour market? In short, should physicians stay or should they go? We try to answer such questions in this work.

2 The Methodology

To approach this problem we have first built an economic model that incorporates the physician workforce as individual agents. The physicians were given decision-making microeconomic fundamentals, and decide whether to emigrate or not based on that set of rules, incorporating information such as job offers from the outside, domestic wage, moving costs, etc. We calibrate the model as close as possible to the Portuguese health labour market. This economic model is then used to experiment with some policy levers, such as raising wages, increasing/decreasing *numerus clausus* or contracts to the public sector, and to observe the impact of those policies in the physician workforce. Secondly, we devised a welfare analysis framework to understand the social impact caused by different policy responses to both physicians and the remaining population, including *laissez-faire* (letting them go) or adjusting wages, *numerus clausus*, etc. We evaluate the impact both when the health labour market is in shortage and when it is in excess of supply, as the current state strongly influences the policy to be prescribed.

To implement the model we resorted to agent-based computational economics (ACE), as these models go beyond Walrasian equilibrium foundations, representative agents and the assumption of market clearing. In a non-Walrasian health labour market, as is the case of Portugal for the reasons aforementioned, an ACE model is a very adequate tool for the problem at hand. The main difference compared to a traditional economic analysis rests on having a simulation model with atomic agents that act and interact according to the same set of equations, or microeconomic foundations, as any other standard economic analysis. Hence, instead of obtaining a purely analytical or numerical decomposition of the economic model, we can actually test it with simulated agents and observe what other nonlinear and analytically intractable relationships may arise out of these interactions. Simply stated, we create virtual economic agents and let them run their lives.

Our simple economy features two types i of agents, physicians H and non-physicians L , a publicly funded health care system run by the government and a private sector that exists for accounting purposes only. The public sector is a highly regulated Beveridgean national health system with salaries fixed by collective bargaining between unions and the government. It features two markets, an health labour market, composed of a supply of physicians S^H and a demand for health care services D ; and a migration market, with a vacancy supply VS and a wage-setting WS schedule. These markets interact through many different channels, including through changes in wages, *numerus clausus*, residency training vacancies, etc.

Figure 1 provides an overview of these interactions.

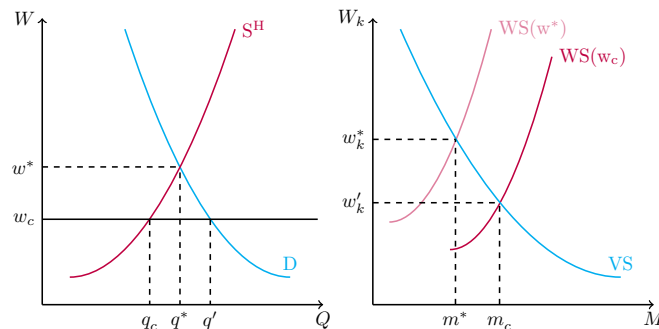


Figure 1: The interaction between the health and the migration market. w stands for the price of labour (wage), q for the quantity of labour and m for the number of migrants. w_c represents the wage table fixed by government.

The migration market arises from individual physician decision-making that lays on four tenets: the utility derived by living in the home country (U), the utility of living in country k (U_k), the moving costs (C) and the disutility of being unemployed or unable to enrol in a residency program (Z). Physicians emigrate if the utility brought by moving abroad outpaces everything else ($U_k > U - C - Z$).

However, a few caveats remain. An empirical estimate of the utility function of the population is required. We assume they are risk-averse towards emigration, which is supported by evidence, but an empirical calculation of the wage elasticity of emigration is also needed.

3 The value to Society

Emigration produces long lasting effects on the health labour market, in this way affecting the productive structure of the economy. Besides changes to the supply of labor, medical emigration may produce positive or negative externalities in other markets as well. Therefore, it is important to analyse its broad impact, particularly to the non-emigrants, as it is known that, a priori, emigration increases the utility of the migrants (otherwise they would not move abroad, unless forced to). This work aims to provide a policy analysis of such issue.

Moreover, this work provides methodologically sound guidelines for policy makers to consider when dealing with an imbalance in the physician workforce. These results suggest that government's intervention only generates a positive outcome to society if there is a shortage in the supply of physicians, and even so it is contingent upon the marginal utility of health care consumption being greater than the consumption of other private or publicly financed goods. In case there is a surplus in the physician workforce, both physicians and the remaining population will be better off if a no-policy policy is enacted.

The Seamless Mobility solution: an integrated route planner, mobile payment and social network for public transport

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The Seamless Mobility solution: an integrated route planner, mobile payment and social network for public transport



IEMS'17

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1 The Challenge

The proliferation of new technologies is revolutionizing the public transport sector, allowing Operators to replace complex and expensive infrastructures by travellers' mobile devices and online management channels and platforms.

Transport Operators are aware of this reality, and are introducing this new channel on their service delivery process. Mobile ticketing systems are an example of such initiatives. These systems can be defined as the purchase and validation of travel tickets through the use of mobile devices, such as smartphones or tablets. Mobile ticketing has several advantages when compared to traditional ticketing systems. They provide passengers remote and ubiquitous access to payment services, queue avoidance, simplicity and

availability. They also allow transport operators to reduce operational costs, improve fare collection efficiency, and enhance their knowledge about customers' behaviour, choices and preferences.

Real-time traffic information is another research topic that has been advocated as increasing satisfaction among customers and increasing the use of public transport. Traveller information systems may enhance the usability of public transport, decrease waiting time, increase feelings of safety and increase overall satisfaction with public transport. However, further adaptation is needed to include other relevant information, such as the price of a journey, as well as the integration with a centralised platform for ticket validation.

The widespread adoption of mobile devices combined with the growing popularity of social media provides an opportunity for communication and collaboration in the public transport domain. Public transport providers have been actively present in social networking services. In addition to their official social networking channels, there are a number of independent user groups for sharing information, typically about a specific service or route. However, the information cannot be filtered or organised straightforwardly in spatial or temporal terms and subscribers are bound to receive the same information despite having unique travel profiles.

In conclusion, some limitations are identified regarding transport-related information management and distribution, as well as flexibility and convenience of payment methods. Therefore, the Seamless Mobility solution aims at design, implement and test an innovative solution for dematerializing travel tickets and provide advanced information to the public through personal mobile devices, addressing some of the limitations identified.

2 The Methodology

The definition of the mobile payment system was based on user-centred design process that follows the international standard 9241 (ISO 9241-210, 2010). According to this approach, the design process addresses the whole user experience and is based upon an explicit understanding of users, tasks and environments. In user-centred design, the user involvement should be active throughout the project life cycle and especially during early stages. This methodology was combined with the WinWin spiral model (B. Boehm, Kwan and Madachy, 1998) which suggests an iterative framework that allows ideas and progress to be repeatedly checked and evaluated. This has the advantage of involving key stakeholders throughout the design and development phases in order to achieve a satisfactory outcome for each group of stakeholders.

Hence, before and during the design of the proposed system, several interviews and meetings were conducted, involving public transport service providers, third-party agents, and technology and software companies. These interviews were important to understand the public transport environment and to identify the needs and goals of each stakeholder in the process. Interviews with public transport users were also carried out in order to identify their main requirements regarding this system.

After this requirements gathering phase, the architecture of the system was defined as well as a set of use cases. The Seamless Mobility solution was materialized in a mobile application, called OneRide. The mobile application was developed through a platform of a multi-operating (Android and iOS) hybrid system. It comprises three main components: (i) mobile payments; (ii) journey planner; and (iii) social network.

The complexity and innovative character of the components and technologies of the mobile application, required an independent assessment before making an integrated evaluation. Thus, the evaluation was conducted in three distinct phases (see Fig. 1). In the first phase the journey planner and social network components were evaluated through a field test and cognitive walkthroughs. The second phase consisted on the evaluation of the mobile payments component and the QR Codes technology performance, through laboratory tests and a field study. Finally, the third phase consisted on the evaluation of all the components integrated through a pilot trial. Following Nielsen and Budiu (2012) recommendation for qualitative user research - 5 participants - the number of participants of the field studies and pilot trial were 6 and 5, respectively. Regarding the analytical evaluation, it was carried out by 5 experts (Nielsen

(1992) recommends between 3 and 5). The evaluation procedures conducted in real environment (field tests and pilot trial) took place in the transport network of the Metropolitan Area of Porto, Portugal.

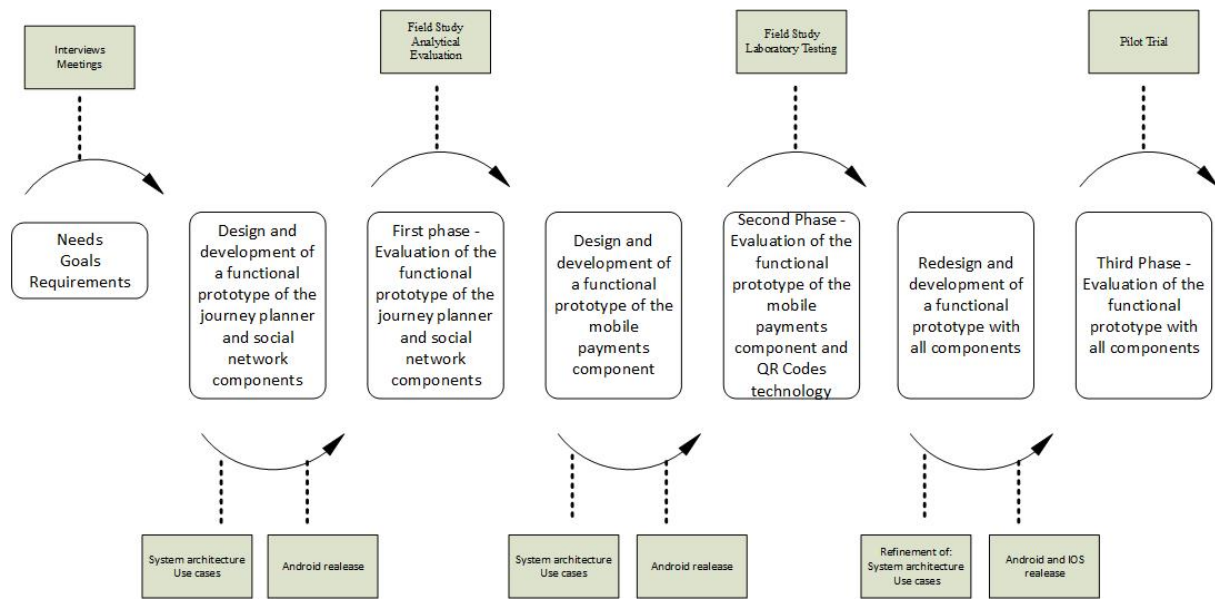


Figure 1: Design stages of the Seamless Mobility solution.

The evaluation results show that users considered the system extremely useful, since it is more convenient than traditional systems. It was also clear that users valued the integration of additional and complementary services with mobile payments, such as information about their journey, maps and schedules. Regarding the social component some users found it difficult to understand the concept, but once they understood they considered it very useful. The use of the QR Codes to perform the payment has shown to be one of the main challenges to be addressed, since lighting conditions, position and distance to the QR Code influences the reading process.

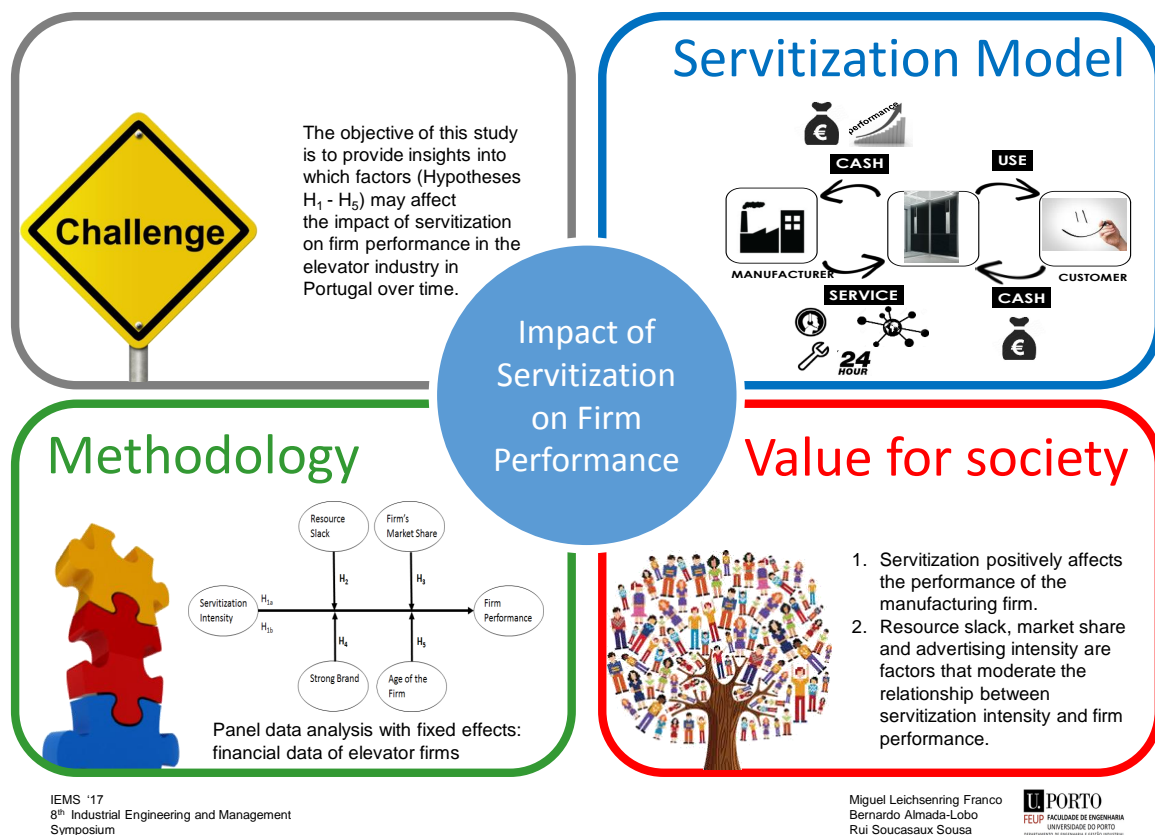
3 The value to Society

The Seamless Mobility Project was conducted by a large consortium composed of a University, technology companies and urban transport operators. It leverages personal mobile devices and ubiquitous communication networks for the dematerialisation of tickets and the offering of timely information to passengers, according to their travel patterns. The main goal is to facilitate and promote public transport usage for passengers, as well as reducing operational costs for transport companies. This allows operators to replace complex and expensive infrastructures by travellers' mobile devices and online management channels and platforms.

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

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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 are 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. From a manufacturer perspective, servitization could lead to higher revenues and profits. Much research has been dedicated to the design and benefits of integrated product service offerings.

Notwithstanding, only a limited number of large-scale empirical studies have considered the relationship between service provision and firm performance. Moreover, the extant evidence suggests a complex relationship between service provision and firm performance; therefore, the simple advice to add services is not likely to always produce satisfactory performance outcomes, the so called service paradox. There is still limited understanding of the performance impact of servitization in manufacturers. It cannot yet be reliably stated which factors affect the impact of servitization on performance. 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 affect the impact of servitization on firm performance in the elevator industry in Portugal over time. The elevator industry was chosen because transition to services is an open issue in this industry and covers a broad spectrum of service offerings, from base to advanced services. Studying a single industry in one country, allows for the natural control of a number of contextual factors that may influence firm performance, as well as for a more granular insight on the factors that impact it.

2 The Methodology

The empirical context for the study is the elevator industry in Portugal. Extant studies on servitization have used several measures for firm performance, including sales growth, shareholder value, and profitability. This study examines the question of which factors may affect the operational margin of the firm, using financial data. The research is based on the analysis of secondary longitudinal financial data obtained from the database SABI Bureau van Dijk. These data cover the period 2006-2014 for all the elevator companies that operate in Portugal. For each of the 116 elevator firms considered, data was collected about total revenues, product revenues, service revenues, operating profit, net profit, number of employees, cost of employment, total assets, working capital, current assets, current liabilities, advertising costs, cost of goods sold and age of the firm. Starting at the company level it was also possible to calculate the aggregate figures for the elevator industry in Portugal. Longitudinal data or panel data are repeated measurements at different points in time on the same firm. Regressions can then capture both the variation over firms and the variation over time. We use panel data analysis with fixed effects to control for time-invariant, unobserved heterogeneity among firms, since it is used to analyse the impact of variables that vary over time and remove the effect of time-invariant characteristics. The panel data is strongly balanced, meaning that almost all firms have data for all the years considered. Figure 1 presents the hypotheses proposed in this work.

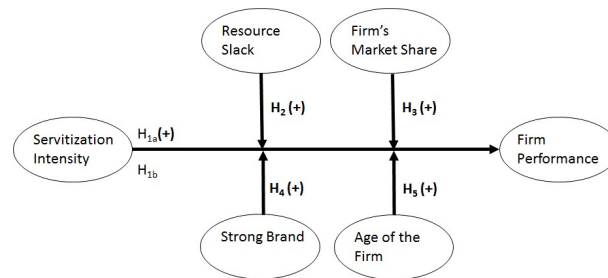


Figure 1: Hypotheses

In H1a, we test a linear effect for servitization intensity. In H1b we test for a nonlinear effect: we expect that the servitization intensity begins to contribute to firm profitability after a critical point in time. In H2 to H5, we look at the moderating effects of several factors on the firms performance, while servitizing.

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 the relationship between service provision

and firm performance. This research extends the literature by providing insights into which factors may lead to improved performance and under which circumstances.

First, the results from this study of the elevator industry support the argument that servitization positively affects the performance of the manufacturing firm. Observing the evolution of the elevator industry over a period of 9 years, we cannot argue that there is a servitization paradox. This may be the case, because the intensity of servitization in the years considered, is by far higher than the critical point found (the critical inflection point when servitization intensity surpasses 56 per cent and profitability of the firm starts increasing again). Since 2010, the industry shows an average servitization intensity well above 60 per cent. The legal obligation of providing maintenance services to the installed base, may also contribute to the high servitization intensity in this industry.

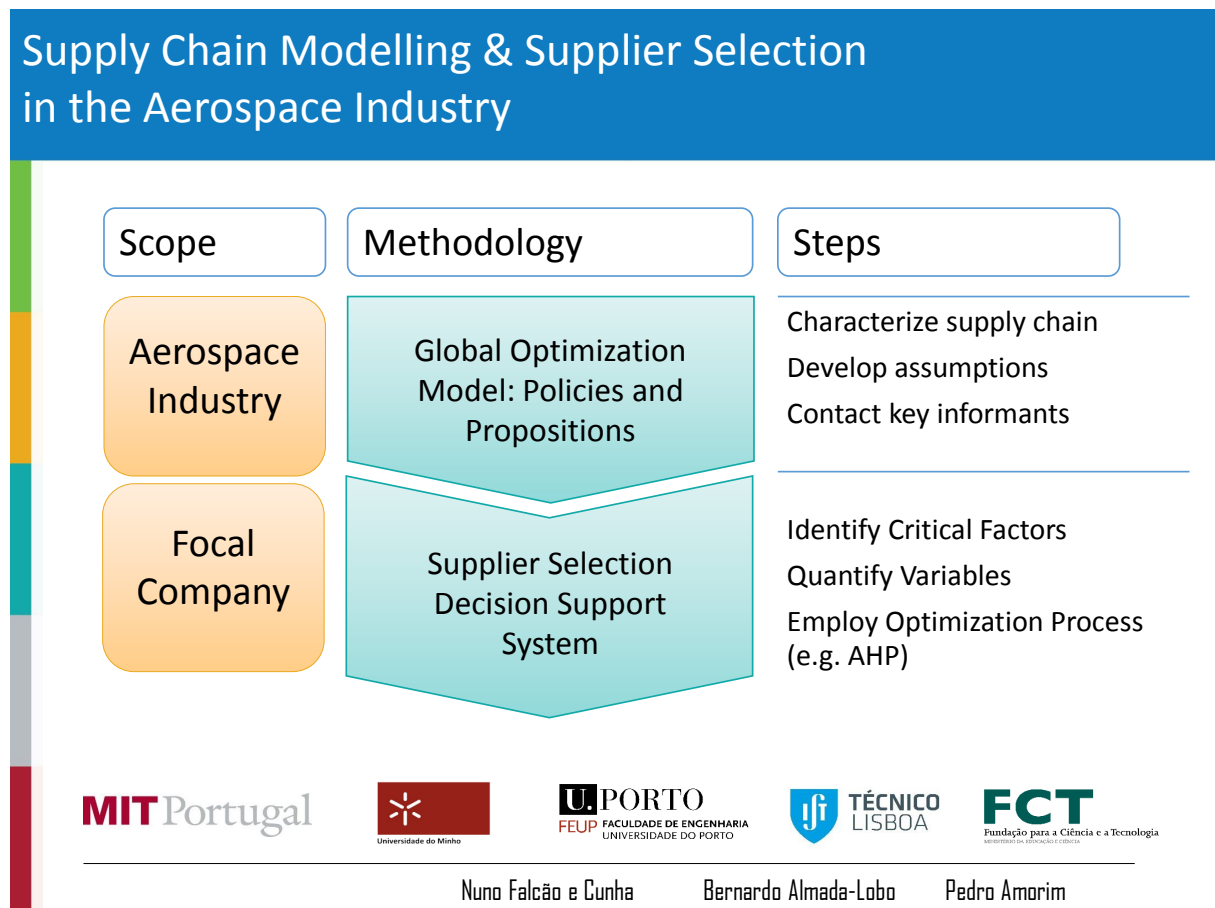
Second, we found out that (a) resource slack, (b) market share, and (c) advertising intensity seem to be relevant factors that moderate the relationship between servitization intensity and firm performance, in the elevator industry, over time. (a) While delivering more services, firms require extensive change and investment through the organization. Higher levels of resource slack seem to help manufacturing firms achieving higher profits while selling more services. From theory we know that slack resource facilitate organisational flexibility and by this process enhances organisational performance. Therefore, manufacturing firms should absorb excess resources during periods of growth. (b) Firms with higher market share are probably more able to leverage existing relationships and to brand resources better, since the customers are more likely to source from a trusted provider. (c) Advertising intensity should help to differentiate the manufacturing firm from its competitors and create barriers to entry by locking out direct competitors who might otherwise provide services to the installed base. A strong brand should help building up a strong relationship between the manufacturer and the customer, contributing to maintain customer loyalty through the entire product life cycle. Therefore, we would expect a positive moderation of advertising intensity on firm performance. Results seem to suggest that a strong brand negatively moderates the relationship between servitization intensity and firm performance, which is not in line with the anticipated effect. This may result from the fact that there is a legal obligation of providing maintenance services and that the maintenance contracts have a long duration. Therefore, the barrier to entry seems to be driven by the existence of a maintenance contract, not from the investment in advertising. During the period of validity of the maintenance contract, no other elevator company can sell services to the same customer.

Our study makes two recommendations for manufacturing firms that are servitizing or that are considering servitization: (a) the adoption of servitization seems to increase the profitability of the manufacturing firm. (b) In order to be successful in the adoption of servitization, manufacturing firms should create slack resources, i.e. a cushion of actual and potential resources in order to allow the firm to adapt to new strategies.

Supply Chain Modelling and Supplier Selection in the Aerospace Industry

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1 The Challenge

The aerospace sector poses many unique challenges as companies competing in this industry become increasingly globalized. The development of a single aircraft model can take up to 15 years, including R&D, design, material selection and certification, which must all be accompanied with the assembly of a suitable supply chain capable of assembling and delivering the final product. As such, the aerospace industry has a considerable strategic component associated with it as projections must be made of market demand years in advance. The long extension of these projects brings with it a certain amount of risk that must be considered and mitigated. A sound supply chain management is fundamental to ensure the venture is sustainable and that it can reach completion.

Large OEMs (Original Equipment Manufacturers) have recently begun to share this risk with 1st tier suppliers which help finance the development stages, and start to receive their money back after the first sale. In exchange, they have a more active role during said development and are given more autonomy in

the management and selection of their own supply chain. Evaluating and comparing the supply chains behind the suppliers in each tier is a complex challenge and one that would represent an important impact within a decision support system for supplier selection.

This research project is a sub-part of the IAMAT project for the introduction of advanced materials technologies (IAMAT) into new product development for the mobility industry. Research groups from the University of Minho, FEUP, IST and MIT are working together towards a product development evaluation framework, targeted at advanced materials, manufacturing technologies and structures for the aerospace industry. The research outlined here is part of the fourth work package, supply chains towards sustainability, in charge of assessing and quantifying supply chain impacts of product design choices. Within this scope, the task at hand is to develop supply chain planning models that will serve as a decision support prototype capable of evaluating the sustainability and resilience of supply chains in the aerospace industry.

The first challenge is then to build a generalized model of the equilibrium supply chain structure for the aerospace sector. Such a representation would describe all stakeholders within the supply chain, including multiple supplier tiers, manufacturing and assembly sites, as well as end-customers. This will potentiate the study of operational trade-offs associated with decisions made during supply chain design which can be, for example, of a geographical nature or to do with means for transporting components between production and assembly sites. A global overview such as this one will analyse viable sourcing strategies, production methods, transportation, storage and other key aspects of the supply chain. The fact that this model will require a comprehensive understanding of the sector and its inner workings makes it a useful starting point that will develop awareness on the particularities of this industry.

In aerospace companies, it is usually the case that each aircraft has its own supply chain associated with it. As such, the second challenge closes in on a specific focal company and will be to develop a planning model for supplier selection, which will very likely have to consider decisions made in the development for a particular aircraft. As discussed above, it is common for each supply tier to directly manage the tier below it, however these decisions will undoubtedly be conditioned or reflect upon strategic decisions made by the OEM. Therefore, selection between suppliers may consider not only technical specifications, but also supply chain decisions made downstream, which will directly influence the resilience and sustainability of the whole supply chain.

2 The Methodology

Before tackling the two challenges outlined above with modelling and optimization algorithms, the initial approach has been to become more familiar with the aerospace sector, which involved an extensive literature review. This included papers describing the supply chain, as well as supply chain management tools and practices for the aerospace industry. Additionally, research done on supplier selection, both for the aerospace industry and for others such as the automotive sector, were investigated along with work done on developing metrics for risk-exposure assessment and management.

The characterization of the equilibrium supply chain structure will rely on the development of a simple representation of the entire supply chain for the aerospace sector, relying on both the literature and contacts with relevant informants to make assumptions on the industry's procedures. These assumptions will cover multiple supplier tiers, transport and storage policies, as well as interactions between stakeholders, including suppliers, OEMs and customers. This model can also provide insight on the impact that different scenarios of market demand, which must be projected years in advance, will have upstream in terms of the supply chain. These assumptions will have associated with them mathematical equations that will be used in an optimization model capable of supporting propositions for profitable development in each section of the supply chain. These propositions will analyse trade-offs from decisions such as transporting parts by ship or by plane and will support strategic decisions by analysing the ensuing costs along the entire chain.

The second part of this project will take the form of a supplier selection decision model. The first step will be to establish critical factors that OEMs consider when choosing between suppliers for projects associated with new aircrafts. These can be associated with the materials used by each supplier or lead

times, but may also be metrics for reliability, sustainability or resilience. Furthermore, it may be relevant to consider what the suppliers themselves value in their own supplier selection, as well as how much autonomy they are granted by the OEM, and how that will impact the supply chain as a whole. Each of these variables will be inserted in an optimization model that will help in objectively comparing suppliers based on the OEMs priorities. Examples of techniques to be considered with this intent are analytic hierarchy process (AHP), Fuzzy programming and data envelopment analysis (DEA).

3 The value to Society

The aerospace industry is one in undeniable expansion, but one that with each new venture carries with it a great deal of risk. In the past, this sector has faced serious issues with delays in production and in delivering finished products to their clients. This has been due to inefficient supply chain management that was unable to keep up with the rapid globalization of the main companies in the field. Furthermore, due to the long lead times associated with the development of the aircrafts, mistakes made in supply chain design may be costly but only detected years later. As such, it is of great importance that suitable tools are developed capable of ensuring a sustainable, resilient and reliable supply chain.

The goal of the IAMAT project as a whole is to optimize innovation in the aerospace industry with an integrated framework for introducing new materials and structural solutions in mobility industries. The research outlined in this abstract will have the more specific aim of evaluating supply chain sustainability and resilience trade-offs in supply chain design related decisions. Embraer, one of the world's largest aircraft manufacturers, will serve as a testbed for the models assembled over the course of the project and, thus, will provide most of the relevant information used within the models assembled throughout this project.


Therefore, the first contribution will be a compilation of policies and propositions on general practices for the global supply chain for the aerospace sector, with the intent of ensuring profitable development. By modelling the equilibrium supply chain structure for the aerospace sector, it will be possible to study operational trade-offs propagated throughout the supply chain for each design choice made along the way. These decisions could be, for example, the choice between different locations for production and assembly plants, choosing local or foreign suppliers, or even opting for a certain means of transportation.

Additionally, a solution methodology will be developed that will act as a supplier selection support system providing insight on metrics associated with sustainability, resilience and reliability for each decision, but also considering product design specifications such as materials, manufacturing techniques, operations costs and lead times.

A Variable Neighbourhood Descent Approach for the Assembly Line Balancing Problem

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A Variable Neighborhood Descent Approach for the Assembly Line Balancing Problem

Challenge

- To provide a quick system for balancing mixed-model line while assigning tasks and operators to a minimum number of workstations while equalising station times.

Methodology

- Devise comprehensive and detailed mathematical models;
- Apply a heuristics according to RPW method;
- A VND is used to provide a sufficiently good solution.

The Value to Society

- Help footwear companies optimizing their resources;
- Provide new solution methods for specific line balancing problems.

Parisa Sadeghi
Sup: Prof. José Soeiro Ferreira - Eng. Rui Rebelo

1 The Challenge

The footwear industry has been advancing to a great extent. That means while in the past a few models were being produced in large numbers, the circumstance changed when this industry began relying on fashion, which led to decreased orders of varied models. Basically, this industry is a diverse sector that is composed of various products for men, women, and children and each with an abundance of models. Normally, the manufacture of shoes includes different procedures such as: cutting, stitching and assembly. The focus of this study is the stitching line that is related to the production of the upper part of a shoe. Stitching line has a crucial importance in this industry since footwear quality is usually determined by this line. Moreover, people's desire plays an important role in this line in a way that changes in their desires leads to changes toward the production of lots of models. Therefore, there are different models

at the same time in the stitching line, and each has a different routing with varied tasks and different processing time.

In this industry both manpower and machine are important, and since the production plan changes rapidly, answering the question how many resources are needed is a crucial issue.

This study, essentially focuses on balancing resources and the way of allocating them. It should be considered that in the stitching line the workpieces are put in boxes then lots will be dealt with. A critical question which will be answered by the manager of the line is related to balancing and allocating tasks to the workstations in a manner that everybody who works approximately at the same time and at the same point do not create queue or bottlenecks.

The Assembly Line Balancing Problem (ALBP) is a NP-hard problem and various assumptions for this problem could be made and each of them is translated into a constraint, such as operators abilities and machine restrictions. In this line there are operators with different skill levels, some of them are experts and others are not. The main aim of this work is to allocate the correct task to the right operator. There are special operators in the company who are the only ones with the ability to perform some tasks. Furthermore, another matter is the machines, which will be allocated to the workstations. The machines in this factory are grouped based on their ability to perform different tasks. The other difficulty of this work is balancing the line while considering the constraint on the type and number of machines. Besides, with each machine only one operator can work, when each operator can work with various machines.

To produce a shoe on a line, it is essential to divide the total work into a set of tasks, each task requiring a certain time; each model has a special production routing that increases the difficulty of the balancing. For example, it is not possible to sew some parts before they have been glued and assembled.

As the generic production plan for the line is known in advance, the main issue raised is the determination of the number of workstations needed to satisfy such plan. Therefore, cycle time of the line can be calculated. Mainly, with regard to this cycle time, the objective is to minimize the number of balanced workstations, however, there is another issue which is smoothing the operators' workload. Therefore, by considering these two objectives this problem is considered as a multiple objective problem.

2 The Methodology

The approach that is proposed here considers boxes as unity and assigns tasks of different models in various boxes to proper operators and machines which is more appropriate in a real manufacturing. This problem was mathematically formulated. However, it is not possible to solve real world problems in relatively accepted time. In addition, an increase in the number of tasks and boxes in the line will lead to the running time increase. In reality further there are work in processes. Therefore, this issue should be considered.

The ALBP considered in this work is solved by a constructive heuristic, that follows, Ranked Positional Weighted (RPW) method but with different adaptations, and then a Variable Neighborhood Descent (VND) is used to improve the solution. VND is one of the best improvement descent methods when it is not a typical technique for balancing problems.

The objective involves the minimization of the number of needed workstations and a convenient operators' allocation to machines so that the workload is smoothed. However, it is not possible to solve real world problems in relatively accepted time. In addition, an increase in the number of tasks and boxes in the line will lead to the running time increase.

In this constructive heuristic, tasks are allocated to operators and machines by using RPW method which is adapted to this case. The algorithm at first phase starts to create one box of each available model in the production plan with 10 pairs inside, then by considering calculated cycle time for those boxes which called first set of boxes allocation will be done. Next it moves forwards to create the following set of boxes, and this process is repeated until all the tasks in all set of boxes are allocated.

Various techniques are used to find a good feasible solution such as having fixed and flexible cycle time

in different set of boxes. The cycle time could be flexible in this manner:

In each set the maximum production time of each workstations will be calculated then it will be compared to the cycle time and if it is lees then the difference could be added to the cycle time of the next set of boxes.

The other issue is considering different sequence of operators in the input data, because this item could affect the solution and further some order of operators could also generate an infeasible solution.

A task is chosen and the algorithm checks if there is only one operator with the ability of manufacturing the preferred task therefore, this task is special and before any other assignments it should be assigned to the picked operator. Figure 1 shows the constructive heuristic steps.

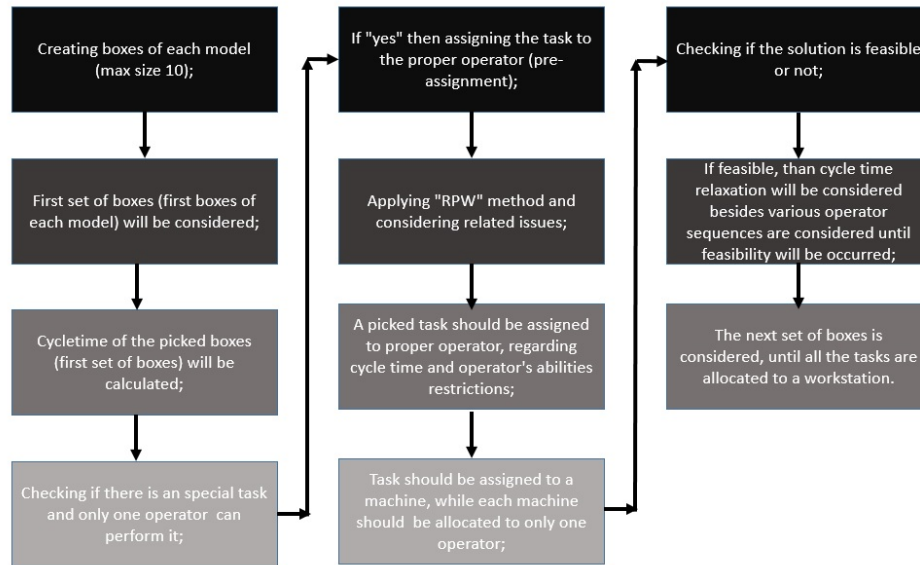


Figure 1: Constructive Heuristic.

Finally, after finding a feasible answer then VND will be applied.

In order to obtain a relatively good solution, all efficient neighborhood spaces are used in this technique and a neighbor of an incumbent solution is obtained by transferring and swapping tasks between workstations, they are explained in the following:

N1: transfer all the tasks of machine m of operator o from all set s to machine m' and operator o' , each task in the same set s ;

N2: transfer one task of machine m of operator o in set s to machine m' and operator o' in the same set s ;

N3: transfer one by one tasks in set s of machine m of operator o to machine m' and operator o' , each task in the same set s ;

N4: swap all task of machine m of operator o from all set s with all tasks of machine m' and operator o' from all set s , each task could be swapped among operators and machines in the same set s ;

N5: if operator o work on more than one machine: swap all the tasks of machine m of operator o from all set s with machine m' and operator o' from all set s , each task could be swapped among operators and machines in the same set s ;

The algorithm applied to the real world problem and at the same time for small instance it gives us the optimal solution.

3 The value to Society

The value to community of the this work are divided to different fields. Firstly, considering the importance of footwear industry in this country and the proposal of a solution approach can help the management on taking decisions and having better utilization of the whole system. We aim at developing a system that helps company optimizing line balancing solutions and will expedite planning and increase resource utilization, by reducing the number of workstations and smoothing operator's workload. Although a particular assembly line is under research, the outcomes may be extended to other companies.

On the other hand as mentioned the balancing problem can be found in many industrial applications, therefore this problem is not just for footwear industry. Furthermore, the proposed method and procedure could be used to other similar industries, caused by a lots of parameters which are considered in this work such as operators, machines and variety of models the algorithm is quick and could be used any time which is needed for real world cases.

Finally, this work with the solution approach could give insight for the mixed-model ALBP field and used technique considers the work in process which could be strictly useful for real applications.

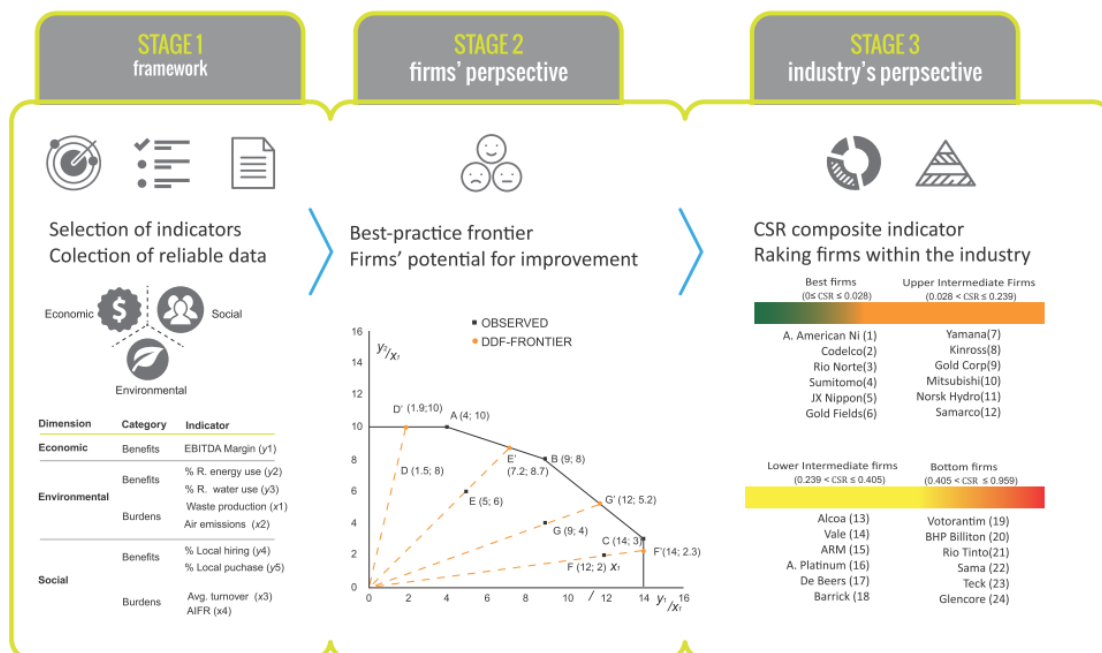
A new method for the evaluation of Corporate Social Responsibility in the mining sector

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New method for the evaluation of Corporate Social Responsibility in the mining sector

Renata Oliveira



1 The Challenge

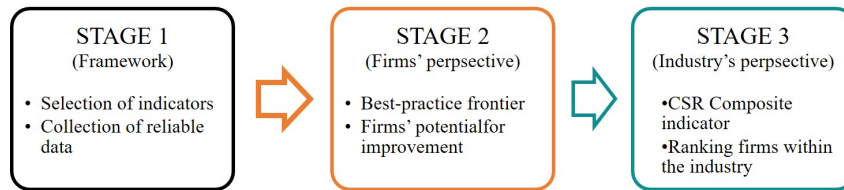
This work focuses on the assessment of Corporate Social Responsibility (CSR) in one of the most controversial industrial sectors: mining. On the one hand, the mining sector is responsible for generating economic and social benefits to local communities and national economies (e.g., automotive industry, agribusiness, pharmaceutical industry). On the other hand, wealth distribution and the mitigation of environmental impacts remain strong challenges for this industry. Firms from this sector are often associated with dangerously high consumption of non-renewable resources, such as water and fossil fuels. For instance, the large amounts of water required to process ores reduce considerably the aquifers in exploited sites, threatening the water sources of local communities. To address this complex theme, this paper proposes an innovative methodology for constructing a CSR composite indicator. This study adopts the

definition of CSR of the World Business Council for Sustainable Development (WBCSD), stating that CSR is the continuing commitment by business to contribute to economic development while improving the quality of life of the workforce and their families as well as of the community and society at large. Therefore, to be considered socially responsible, the firms should achieve consistently and consensually high-performance standards on all their economic, environmental and social practices. In this sense, the main contribution of this work is to propose a new method for the evaluation of CSR of mining firms that supports organizational efforts towards performance improvement.

2 The Methodology

We propose an evaluation of CRS following a three-stage procedure (see Figure 1). Stage 1 involves the identification of the dimensions underlying the evaluation of CSR in the mining sector, as well as the most appropriate indicators to be used, taking into account the availability of reliable data. At this stage, we propose a comprehensive framework that takes into account the three dimensions of the Triple Bottom Line (TBL), including economic, environmental and social indicators reflecting both desirable and undesirable factors (see Table 1). The indicators selected cover key features of CSR defined by international guidelines and standards (e.g., GRI sectorial guidelines, ISO 26000:2010) and research related to corporate sustainability. These features are frequently associated with wealth distribution, decent work, local development and the use of renewable resources. Stage 2 estimates a composite indicator of CSR using optimised weights. These weights are firm specific, such that all firms are analysed under the best possible light. By recurring to this technique, the evaluation of CSR is based on a benchmarking exercise, where the potential for improvement in the different dimensions of CSR is uncovered by a comparison with the best-practices observed in firms within the same industry. In particular, we used a Directional Distance Function model (formulation (1)) that searches for proportional improvements in all indicators under assessment, leading to higher benefits and lower burdens until the reaching the best-practice frontier that envelops the practices of the firms analysed. Stage 3 involves the use of a goal-programming model, specified in (2), to obtain a common set of weights (CSW), reflecting a consensual view of the industry's performance. This consensual view is obtained via optimization techniques, which facilitates the construction of a ranking based on the real features observed in the industry rather than the outcomes of negotiations, that might lead to subjective weighting systems.

Figure 1: New method for the evaluation of CSR in the mining sector



In the multiplier model (1), y_{rj} are benefits generated and x_{ij} are burdens imposed on the planet by DMU

$$\begin{array}{l}
 \min \beta_k^{DDF} = - \sum_{r=1}^s u_r y_{rk} + \sum_{i=1}^m v_i x_{ik} \\
 \text{s.t.} \sum_{r=1}^s u_r g_{yr} + \sum_{i=1}^m v_i g_{xi} = 1 \\
 - \sum_{r=1}^s u_r y_{rj} + \sum_{i=1}^m v_i x_{ij} + c \geq 0 \\
 c \in \mathbb{R} \\
 u_r, v_i \geq 0
 \end{array} \quad \begin{array}{l}
 (1) \\
 k = 1, \dots, n \\
 j = 1, \dots, n \\
 r = 1, \dots, s \\
 i = 1, \dots, m
 \end{array} \quad \left| \quad \begin{array}{l}
 \min \sum_j^n d_j \\
 \text{s.t.} - \sum_{r=1}^s u_r^{gp} y_{rj} + \sum_{i=1}^m v_i^{gp} x_{ij} - d_j = \beta_j^{DDF} \quad j = 1, \dots, n \\
 u_r^{gp}, v_i^{gp} \geq 0
 \end{array} \quad \begin{array}{l}
 (2) \\
 j = 1, \dots, n
 \end{array}$$

j . Similarly, y_{rk} and x_{ik} are the benefits and burdens observed in firm k under assessment. The DMUs in this study are mining firms. The weights $u_r (r = 1, \dots, s)$ and $v_i (i = 1, \dots, m)$ are the decision variables respectively associated with y_{rk} and x_{ik} during the assessment. The directional vector ($g = -g_{x_i}, g_{y_r}$) indicates the direction of change for the benefits and burdens. This model computes an inefficiency score for every firm k (β_k^{DDF*}) with optimized individual weights (u_r^* and v_i^*). In model (2), the single weights $u_r^{gp} (r = 1, \dots, s)$ and $v_i^{gp} (i = 1, \dots, m)$ are the decision variables associated to the benefits (y_{rj}) and burdens (x_{ij}) of j . The equation in the second line of (2) is the primary goal, which aims to obtain a common set of weights that minimizes the positive deviations (d_j) in relation to the original CSR score β_j^{DDF} . This should be interpreted as an attempt to reach a consensual weighting system that minimizes deviations in relation to the original CSR scores of model (1), which are based on fully flexible and DMU specific weighting systems.

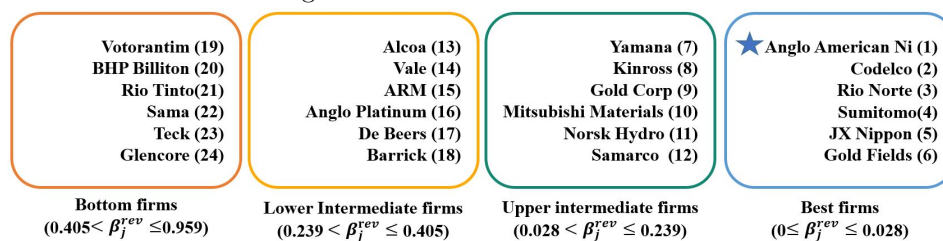
A dataset of 24 large mining companies was assembled with data published by the Global Reporting Initiative (GRI) and corporate financial reports. Only DMUs that reported their annual results accordingly to the sectorial guidelines of GRI with external assurance of information were taken into account to compose the set. The data collection relied on reports published between 2012 and 2014. The reference year for the assessment is 2012 as this is the most recent year available with the smallest number of missing values (4.5%) in all the dataset. All missing values in the sample were replaced by the worst observed value for each indicator. This approach was meant to ensure the firms' performances were not benefited unduly with the lack of information.

Table 1: Indicators considered in the assessment framework

Dimension	Category	Indicator	Units
Economic	Benefits	EBITDA Margin (y_1)	USD/USD
Environmental	Benefits	% Renewable energy use (y_2)	GJ/GJ
		% Renewable water use (y_3)	Mil. m^3 / Mil. m^3
	Burdens	Waste production (x_1)	tons/Mil. USD
		Air emissions (x_2)	tons/Mil. USD
Social	Benefits	% Local hiring (y_4)	observations / workforce
		% Local purchase (y_5)	observations / workforce
	Burdens	Avg.Turnover rate (x_3)	dismissed workers / workforce
		All injury frequency rate (x_4)	events /20000 hs

Results from stage 2 indicate that 15 firms were assigned a CSR score (β_j^{DDF}) greater than zero, meaning that they have scope for improvements in their CSR practices. The revised composite indicator obtained on stage 3, based on the industry's CSW (β_j^{rev}), allowed the construction of a ranking reflecting firms' CSR practices. Anglo American Ni occupied the first position in the rank, meaning that it has the best practices in terms of CSR practices within the mining sector ($\beta_j^{rev} = 0$). The remaining 23 firms occupied the subsequent positions, with scores ranging from 0.002 (Codelco) to 0.959 (Glencore). The firms ranked were categorized in four groups according to the quartile they belong in terms of CSR (Figure 2).

Figure 2: Rank of the firms studied



3 The value to Society

The assessment of CSR of mining firms brings several contributions to society. The first contribution is the delivery of a comprehensive framework that allows for an objective multidimensional evaluation of CSR for mining companies. The framework developed takes into account the firms' burdens and benefits conveyed to society, with special attention to local development practices and the use of renewable resources. This new method can contribute towards a consensus in the evaluation criteria and the dimensions to be considered in this field. The second contribution regards proposing an innovative method to estimate a CSR composite indicator, integrating optimization models. The composite indicator method proposed reveals potential to improvement of each firm, taking into account its profile in terms of strengths and weaknesses. The third contribution is the proposition of an integrated perspective of CSR performance for the mining sector that can be valuable for decision makers or local/national authorities to analyze the impact of these firms on society and ecosystems on common ground. The construction of a firms' CSR rank can promote formative discussions in this field, leading to higher awareness of public opinion in this important topic. To the best of our knowledge, the integration of these methodologies for the assessment of CSR is unprecedented.

Acknowledgments

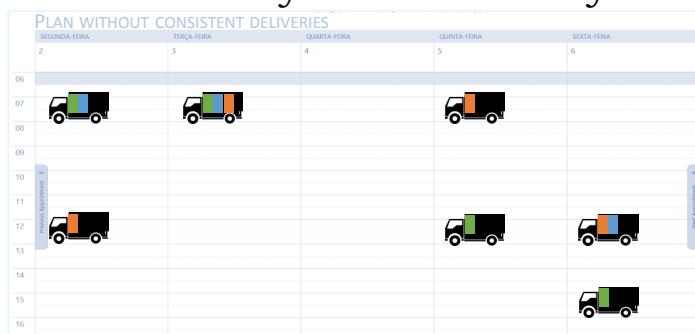
The authors wish to acknowledge the financial support of UEPA, CAPES (BEX 19131127).

Consistent Multi-Compartment Vehicle Routing Problem for the Grocery Retail Industry

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Consistent Multi-Compartment Vehicle Routing Problem for the Grocery Retail Industry



Challenge

Plan consistent deliveries of products to the stores



Methodology

Always enforce consistency and penalize transportation costs

OR

Balance consistency and transportation costs

Application to real world cases requires the use of heuristic approaches

Value to Society

Smooth the in-store operations

- Receiving process
- Shelves replenishing process

And the distribution center operations

- Picking process
- Trucks planning

INESC TEC and FEUP, KU | Sara Martins, Manuel Ostermier, Pedro Amorim, Alexander Hübner, Bernardo Almada-Lobo

1 The Challenge

In the past, studies on vehicle routing problems (VRP) were only focused on transportation costs. Recently, variants of the VRP that consider other operational costs have been proposed, such as holding and ordering costs in the case of the inventory routing problems (IRP) and the loading/unloading costs in the case of multi-compartment routing problems (MCVRP). Despite the costs incurred in the distribution being the main driver for designing the routes, the increased market competition is forcing companies to analyze in more detail the quality of the service provided. Consistency in the deliveries, in several dimensions, is one of the key factors that influences the perceived quality of the service.

The concept of consistency in VRPs (ConVRP) was introduced in the last decade and is presented in the literature with three dimensions: arrival time consistency, driver consistency and delivery consistency. The idea is to perform deliveries to the customers around the same time of the day, using the same driver, with a constant interval between deliveries and stable quantities.

This work proposes a fourth dimension of consistency for the specific case of MCVRP in the grocery retail industry. Grocery retailers have to supply brick-and-mortar stores with products that require different temperature conditions. These temperatures need to be secured not only in the distribution center and stores but also during the transportation. Nowadays, retailers can use new technological vehicles that allow to separate products in different compartments, each securing distinct temperatures. Therefore, by using MCVs a customer that places orders that require distinct temperatures on a given day can receive them all together at the same time by one vehicle. The challenge in the distribution planning with MCV is to decide not only which customers to visit by each vehicle but also, which of the customers orders (which segments) should be delivered.

Making a routing plan independent for each day might lead to a solution where a customer receives the different products in distinct ways along the days. Figure 1 shows an example where customer A receives on day 1 the different products in separated routes, on the second all together and on the third day a combination of both.

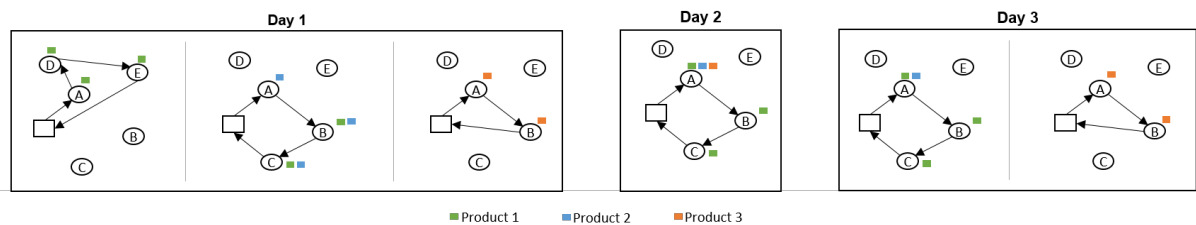


Figure 1: Example of the route planning involving customer A in three consecutive days, without consistent deliveries

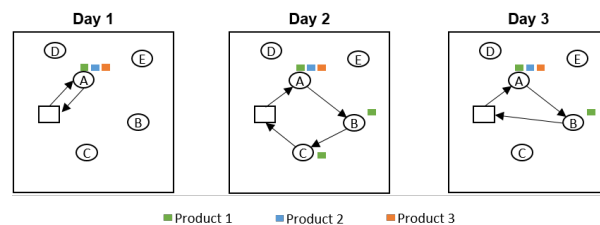


Figure 2: Example of the route planning involving customer A in three consecutive days, with consistent deliveries

However, if an integrated planning is made for a given period, forcing the same type of deliveries along the days, a consistent service can be provided, as in the example presented in Figure 2. If a store has defined when the deliveries will be made (arrival time consistency) and what type of load it will receive (segment consistency), then it is able to plan its workforce and also the process of receiving more accurately.

Therefore, the fourth consistency that is proposed relates to the MCVRP for the grocery retail industry in which the distribution of the different products should be planned taking into consideration the consistent delivery of products combination along the days.

2 The Methodology

The MCVRP is a variant of the capacitated vehicle routing problem and is therefore NP-hard, as well as its extension to tackle consistency (ConMCVRP). Solving exactly an NP-hard problem is only possible

for small instances and, consequently, heuristic approaches need to be developed to obtain solutions for practically relevant problem sizes.

In the literature there are two types of approaches proposed to tackle ConVRPs: (1) approaches that enforce the consistency by means of hard constraints, only minimizing the transportation costs; (2) approaches that trade-off the transportation costs and consistent service using multi-objective functions.

Most of the approaches rely on template routes as basis for their heuristic procedure, which is usually a Large Neighborhood Search with remove and insertion operators designed to improve a pre-defined type of consistency.

Because in the MCVRP a customer can place more than one order from different segments to be delivered in the same day, this work will develop new operators to cope with the specificity of the MCVRP and the type of consistency in question. Different solution approaches are still being studied to understand which is best suited for this problem. The complexity of solving this ConVRP variant will be analyzed, as well as, the impact of enforcing the consistency in MCV.

3 The value to Society

The ConVRP for single compartment vehicles has been studied in the literature and its advantages in providing a better service to the customers have been discussed. The literature shows that by allowing a small increase in the transportation costs a considerable improvement of the service can be achieved. This work aims to analyze similar trade-offs for the case of the ConMCVRP.

By making more consistent deliveries to customers using a ConMCVRP we expect them to be able to manage more easily their internal operations because they know in advance when and what products they will receive on a given day. Therefore, stores can schedule their workforce in a way to have sufficient staff to process the products received and the process itself will be more efficient if the combination of segments received remains stable for a certain period of time. Regarding the distribution center, the planning of more consistent deliveries simplifies the planning of the trucks and the respective loading.

Quantitative results on the impact of ConMCVRP will still be analyzed in the next steps of this work.

Acknowledgments

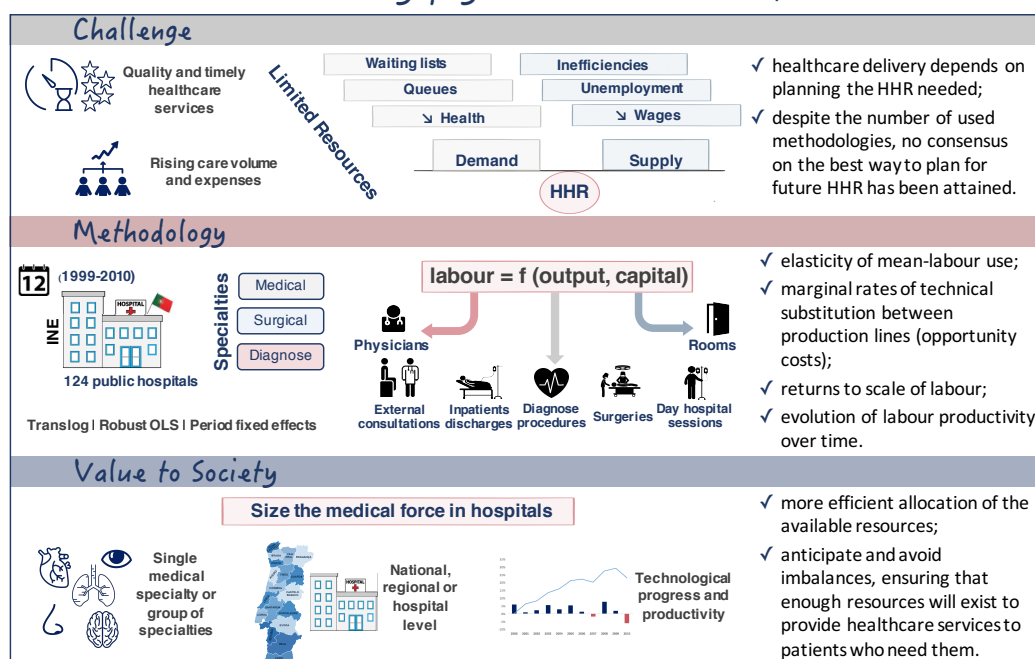
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A labour requirements function for the Portuguese health system: how many physicians will we need?

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*A labour requirements function for the Portuguese health system:
how many physicians will we need?*



1 The Challenge

Ideally, a health system provides quality and timely care services, contributing to a healthy population. However, most health systems have been facing rising care volumes and expenditures, which is a very significant problem considering that resources are limited.

One of the most important tenets of a health system is the health human resources (HHR): no health system can deliver healthcare services without them. Hence, ensuring healthcare services delivery is crucially dependent on both the prediction of the future level and mix of the demand for healthcare services and the estimation and planning for the HHR needed to properly deliver the demanded services. Mismatches between the demand and the supply for HHR from a poor planning may lead to several economic and social problems to society: while a surplus can cause inefficiencies, unemployment or downward pressure on wages, a shortage can seriously compromise patient health as a result of insufficient quantity and quality of medical care, queues or waiting lists. Thus, planning the HHR is pivotal to ensure

that the health system can efficiently reach health goals. In fact, health human resources planning has been identified as the most critical constraint in achieving the wellbeing targets set forth in the United Nations' Millennium Development Goals.

Although planning the HHR demand is a fascinating and widely researched topic, and despite the number of methodologies that have been used, no consensus on the best way of planning for future HHR has been attained in the scientific literature.

The work hereby presented is part of an approach which aims to build a comprehensive and thorough study on the demand for healthcare services and resources. Through an extensive empirical analysis of the Portuguese National Health System, we aim to develop an econometric model to estimate the workforce required to deliver a certain level and mix of healthcare services, accounting for both the labour productivity and the technological progress. This work's main objective is to empirically quantify the relation between hospital care services and the number of physicians needed to provide those services, contributing to the knowledge about hospital production and improving HHR forecasting accuracy.

Our approach differs from previous studies by conjoining three main aspects. First, we analyse hospital care services. Although the primary care has been broadly researched, surprisingly not enough attention has been given to hospital care. Second, most of the studies using econometric models to quantify the relation between healthcare services and human resources have focused on production functions. In our study we consider an input requirements function to model this relation, a specification that is centred on the assumption that the production is exogenous and the labour is endogenous and can be planned and sized according to the needs. Finally, we use panel data for the estimation when most of the previous works have used a purely cross-sectional approach. Our approach may improve the statistical reliability of the results and allows the analysis of the labour productivity evolution and its impact on the healthcare services delivered over time. To the best of our knowledge, no such application of a similar approach to HHR planning exists.

2 The Methodology

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

Using data from the Annual Survey of Hospitals conducted by Statistics Portugal institute (INE), we construct a panel dataset with information about the activity and the resources of each one of the 124 Portuguese public hospitals and hospital centres, by medical specialty, for the period 1999-2010.

Afterwards, considering a labour requirements function (LRF), an econometric model is proposed and applied to the final panel data, that comprised more than 1200 observations of hospitals capacity and services utilisation. The LRF is the inverse of the production function: while the production function gives the maximum amount of output that can be produced with a given amount of inputs (labour and capital), the labour requirement function gives the minimum amount of labour that is required to produce a given amount of output, for a certain level of capital. The main difference between the two frameworks, and in which the main advantage of the input requirements function relies, is that in the production function the amount of labour is considered to be exogenous and the outputs endogenous and, in our case, health decision-makers do not control for the amount of demanded healthcare services (production is exogenous), but they are able to size the health workforce in accordance to the expected demand (labour is endogenous). We represent labour by the number of physicians and use the number of rooms as a proxy for hospital capital. The main production lines of a hospital are considered as outputs: external consultations, inpatient discharges, diagnose procedures, surgeries and day hospital sessions. The fifty-two specialties are then grouped in three major groups of specialties: surgical specialties, medical specialties and diagnose specialties.

In order to estimate the model we assume a transcendental logarithmic form (translog) as the parametric functional form on the LRF, as it yields several interesting benefits: 1) it is a very flexible form that

does not assume perfect substitution between inputs 2) despite assuming a nonlinear relationship between output and inputs, it can be used for a second order approximation of a linear function and 3) after testing for the second order terms relevance we conclude that the translog form is superior to the traditional Cobb-Douglas form.

Our econometric model is then estimated in Stata for each one of the three groups of specialties, using period fixed effects and robust estimators of the variance-covariance matrix. From the obtained results we were able to calculate: 1) the elasticities of mean-labour use with respect to each one of the five production lines, 2) the marginal rates of technical substitution between different production lines, which can be seen as the opportunity costs of physician's time, 3) the returns to scale of labour and 4) the evolution of labour productivity over time, based on the year effect estimated for each of the 12 years considered.

3 The value to Society

Our approach to the estimation of the required healthcare workforce yields into a simple yet very efficient tool on sizing the medical force in hospitals.

Planning for HHR based on our model can be done both for a single medical specialty or for a group of specialties, at national, regional or hospital level. By accounting for the technological progress and for the productivity of health professionals, our approach results in more reliable and accurate previsions. Furthermore, the obtained estimations provide a better understanding on the delivery of healthcare services, some interesting insights on physicians' opportunity costs throughout different healthcare services and enable a more informed and efficient allocation of the available resources.

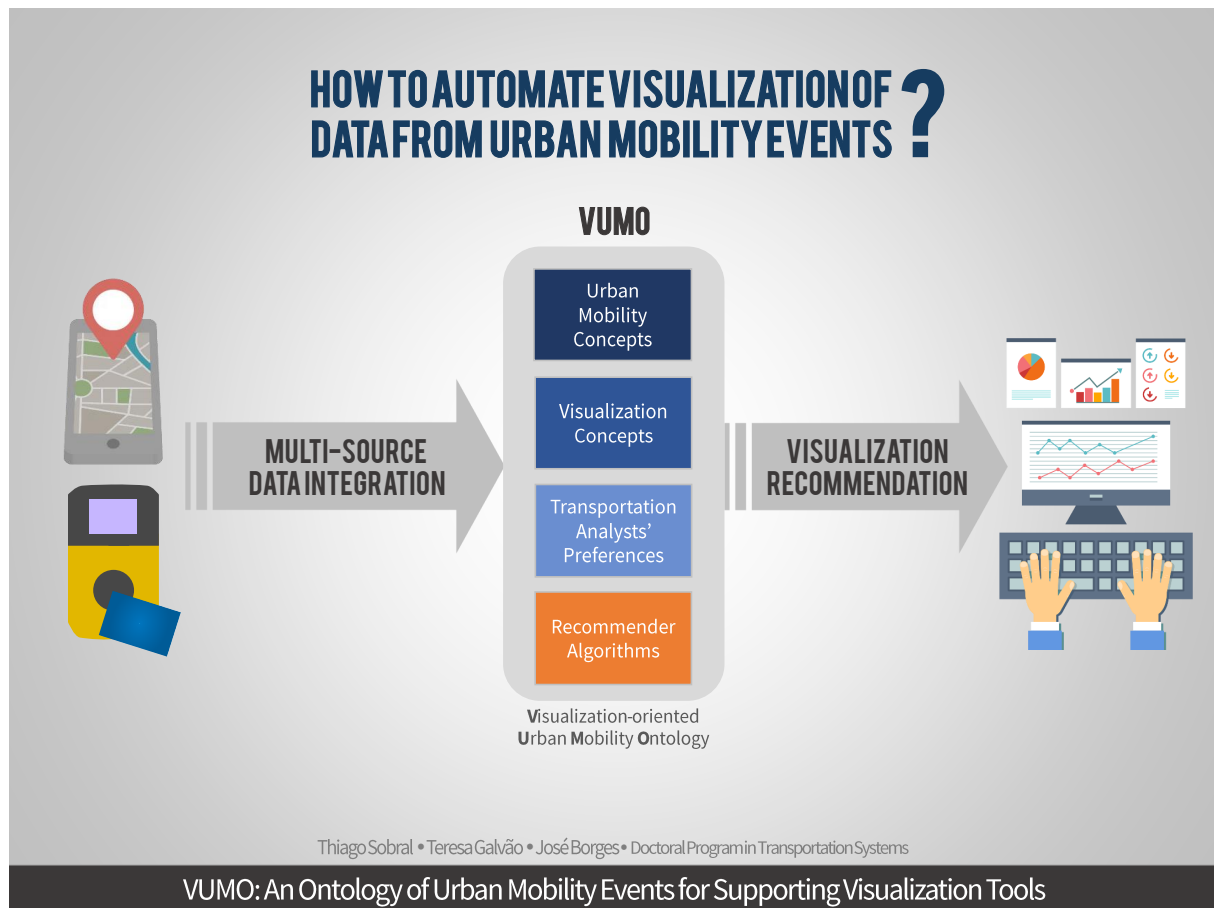
Hence, by creating a model which estimates the required workforce for healthcare delivery we hope not only to make a scientific contribution to the field, by developing a ground-breaking approach to healthcare workforce planning, but also to provide a decision support tool to assist HHR policymakers anticipating and avoiding imbalances and their economic and social consequences, ensuring that enough resources will exist to provide healthcare services to the patients who need them.

Finally, and besides the overall value of the topic, the problem is real and of paramount importance for countries such as Portugal, where shortages of physicians have already been reported.

An Ontology of Urban Mobility Events for Supporting Visualization Tools

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1 The Challenge of Visualizing Urban Mobility Data

Intelligent Transportation Systems (ITS) generate massive amounts of data. Nowadays, Information Visualization techniques are acknowledged by transportation analysts (domain experts) as a powerful resource for assisting the process of exploratory data analysis. Nonetheless, these techniques are not always used in practical contexts due to technical and human limitations. Such lack of use creates a gap between theory and practice.

From a technical perspective, ITS data are structurally heterogeneous, as they are generated by different system specifications. Visualization tools usually require a dataset with a specific structure, which impairs their reuse and interoperability with other datasets.

With respect to the human standpoint, the choice of an appropriate visualization for a dataset is nontrivial task. Visualization knowledge is required in order to properly encode data into visual tokens. Failure to

do so might hinder the identification of hidden patterns and features in data.

Our research aims to foster the development of semi-automatic visualization tools for urban mobility analysis, with focus on events data, such as ticket validations, journey plans, traffic sensing, and the like. By semi-automatic, we mean tools capable of recommending visualization techniques based on data characteristics (structural knowledge) and subjective user preferences and perceptions about visualizations (empirical knowledge).

We posit that there is a need for visualization tools that offer enhanced support to data from multiple sources, and that are able to help domain experts to select appropriate techniques for the data they own. Put briefly, we strive to reduce the technical burden that negatively impacts the use of visualization tools in practical contexts.

Ontologies and Semantic Web Technologies can help to reduce the gap between theory and practice. An ontology is a semantic model that formalizes concepts of one or more domains of knowledge, and provides an abstraction layer for integrating data from multiple sources. This process provides semantics to data, which computers can use to automatically discover new knowledge, based on logic reasoning rules that can be defined.

The main contribution of this research is the VUMO ontology, which stands for *Visualization-oriented Urban Mobility Ontology*. VUMO provides a formal model of concepts related to urban mobility events and visualization theory. Developers (researchers and practitioners) can use it as a foundation for semi-automatic tools oriented to transportation analysts.

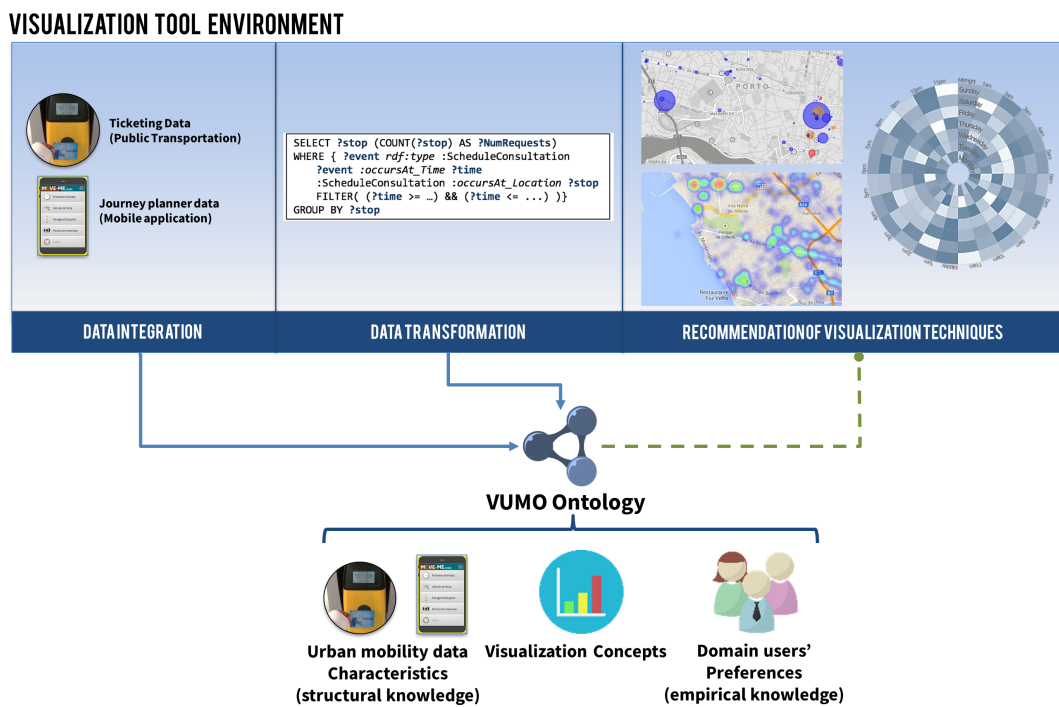


Figure 1: Use case of a VUMO-based visualization tool (top), and the ontology components (bottom).

2 The Methodology

In order to set the foundations of our ontology, we study a variety of ITS datasets from cities like Porto and London, to identify concepts that are often present in that type of data. This process also requires a formal understanding about how space and time is modeled in those datasets. Visualization concepts are retrieved from acknowledged theoretical works. The ontology is built in Web Ontology Language

(OWL¹).

VUMO also features logic rules to support the recommendation of visualization techniques. A distinctive feature is the ability to formalize not only their intrinsic, static features (e.g. visual tokens, spatial and temporal dimensionalities), but to semantically assert and infer complex criteria like their compatibility and appropriateness on regards to data types and user preferences. Compatibility relates to a successful match between extracted data and a visualization technique at its pure structural level. Appropriateness is asserted in terms of human perception factors (empirical knowledge). Such distinction is important: a visualization might be compatible with a data set, but not appropriate to depict it. Accounting for subjective factors is inherent to the visualization process, thus they cannot be disregarded.

In Figure 1, we show a use case of a hypothetical visualization tool environment based on our ontology. Firstly, the user selects the desired datasets. At the end of this stage, data would be already integrated and embedded with semantics. Secondly, the user selects the desired data transformation (e.g. queries). Based on inputs and output data, a tool recommends visualization techniques, ranked by appropriateness.

For the recommendation stage, two approaches are simultaneously adopted, as this process involves structural and empirical knowledge. The former is inferred by embedded meta-queries, which analyze the structure of queries. Empirical knowledge is inferred by specifying Collaborative Filtering techniques, which gather users' perception about visualization techniques in several dimensions (e.g. effectiveness, visual clutter, complexity) and users' analytic profile (e.g. strategic or operational). Finally, we define an algorithm that suggests the most appropriate visualizations based on accumulated knowledge. A user is able to rate suggestions. Such information is also considered for further recommendations.

To evaluate VUMO in practice and assess the relevance of our approach, we aim at developing and evaluating a functional prototype with analysts. It is supposed to be tested with real data and a sample set of visualization techniques.

3 The value to Society

Semi-automatic visualization tools facilitate the users' workload by reducing the technical burden often found in tasks such as data integration and transformation, and visual encoding. Such tools allow analysts to concentrate their available time on exploring data, rather than dealing with technical stepping stones.

From our experience, analysts show considerable interest in thoroughly using Information Visualization techniques to complement their *toolbox*, which often consists of Geographic Information Systems and statistical software. Unfortunately, some analysts state that such techniques are still distant from practical contexts.

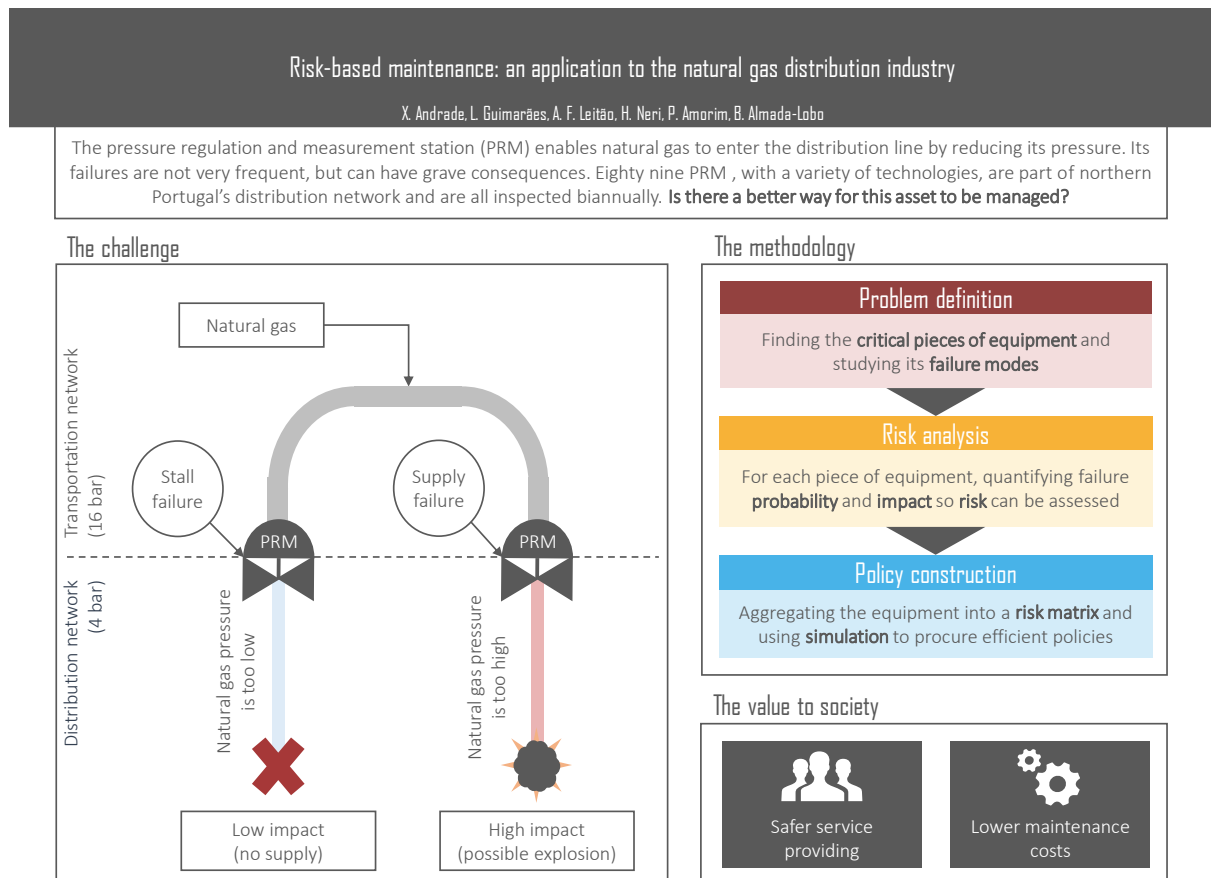
We expect that our work contributes to shifting the researchers' focus towards developing visualization tools that can effectively reach transportation analysts in practice, and enhance their decision making activities. The VUMO ontology will be available, for reuse or modification, to researchers, developers, and domain experts willing to develop tools according to our approach.

¹The creators of the Web Ontology Language coined the acronym OWL instead of WOL, due to aesthetical reasons.

Risk-based maintenance: an application to the natural gas distribution industry

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1 The Challenge

Companies are facing an ever increasing pressure to improve their performance and therefore, operational efficiency is increasingly relevant. Being technologically up-to-date and managing the societal impact of its activities are essential criteria of an organization's efficiency. Consequently, asset management, consisting in the coordinated activity of an organization to realize value from assets, becomes a rather pertinent matter of research and practice.

In this work, our goals are to define, design and validate a maintenance strategy that is adequate to an utility industry with high-impact failures. From a generic objective, we construct a particular risk-based approach, which is promising in reducing risk and maintenance costs. Although the choice of a maintenance strategy requires knowledge of an organization's objectives and aims to be aligned with

them, this perspective will not be prioritized. Alternatively, the maintenance management aspect of asset management will be greatly emphasized in this work, as the objectives of this approach are to increase availability and reduce the impact of breakdowns, allowing the asset to be properly exploited.

We instantiate the risk-based maintenance (RBM) methodology for a critical piece of equipment in the gas distribution industry, that comprises every step from the choice of the equipment to the definition of maintenance policies. In order to develop RBM policies, we undertake a consequence and a reliability analysis of the equipment, allowing us to assess risk. This enables the development of a RBM strategy which, in later stages, can be complemented with the adequate condition monitoring and maintenance practices.

To demonstrate the applicability of our work, we present the results of a collaboration with a Portuguese natural gas distributor. In order to find a better balance between cost, risk, and availability the company's maintenance strategy was tested and compared with others developed with the RBM methodology.

2 The Methodology

As described in Figure 1 our methodology starts with the choice of the equipment, followed by the study of its failure modes. The pressure regulation and measurement station (PRM) is a crucial equipment for the gas distribution business. While gas is fed at a high pressure through a transport network, the PRM reduces its pressure so it can be supplied to consumers. By studying the equipment, we are able to underline two major occurrences that happen in case the PRM fails to reduce the pressure: (1) natural gas supply is cut off by the security system, (2) natural gas is supplied at a dangerously-high pressure. We know that, though each type of failure can be nefarious, their expected frequency is low, moreover these occurrences are not preceded by any measurable symptom. Therefore, RBM is a fitting strategy for this type of equipment.

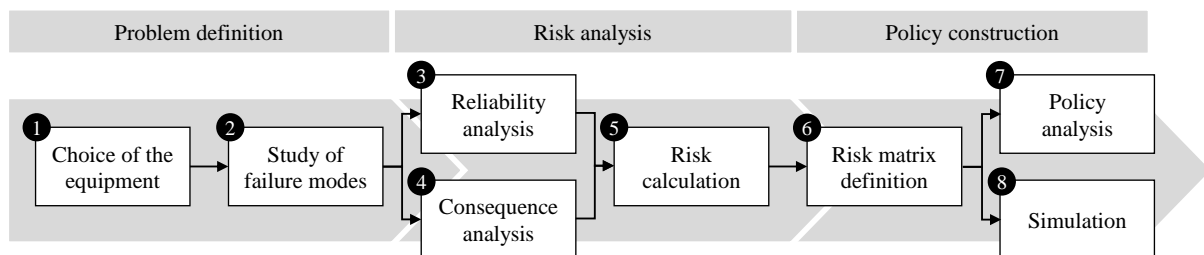


Figure 1: The approach is divided into three phases: (1) problem definition, where the business and equipment is studied, (2) risk analysis, where the qualitative knowledge gathered in the first task is quantified, and (3) policy construction, where the qualitative data is used to build maintenance policies.

Both the consequences of each type of failure, and the probability of each failure mode to occur is computed. The product of these measures, for each piece of equipment, allows us to appraise risk. In order to determine the equipment's reliability, at a given age, we use the the hazard functions of each piece of the PRM's sub-equipment and derive the expression the of the probabilities of each failure mode using block diagrams. The consequences of each type of failure, in each piece of equipment, are computed by the weighted sum of five normalized categories: (1) Lost supply, (2) Affected clients, (3) Affected high-priority clients, (4) Material damages, (5) Fatalities. Then, the weights for each category are determined by the analytic-hierarchy process (AHP) allowing the alignment between our measure of risk and the objectives of the company's maintenance management team.

To facilitate the development of new maintenance policies, the equipment is plotted in a risk matrix, grouping the equipment by expected consequences and frequency of it failures. The time between maintenance actions is tested for each section of the matrix, permitting policies to be determined. The risk matrix accounts for failure frequency and impacts, and failures in different sections are assumed to be independent. In order to test and compare maintenance policies, a discrete-event simulator was developed. The number of failures, maintenance costs, and expected consequences can be estimated by the

simulator, assessing the performance of a policy.

3 The value to Society

As contributions, this study adds a comprehensive instance of the application of the RBM methodology to the literature. We define and model failure modes for the PRM. Furthermore, it provides a multiple-objective approach to be used in settings similar to those described above. We also shed light in the effects of the variations in inspection frequency, for this particular case, in addition to the various methods for accounting consequences and dealing with the lack of maintenance data provided.

With the application of our methodology in the case study, we estimate an 8% decrease in overall maintenance costs without any increase in risk. Within tolerable limits for the decision maker, a reduction in costs as sizable as 33% is possible. A broad interpretation of these new practices is considering that inspections were reallocated to the most critical pieces of equipment in the gas distribution network. Additionally, risk was quantified allowing the decision maker to trade it off with savings.

In the natural gas distribution industry, RBM is a step forward to achieve safe and efficient maintenance policies. We found possible to increase the studied company's economic performance. Furthermore, a safer and more reliable distribution, from which every stakeholder can benefit, is possible. Throughout the research, the company was provided with the developed tools and knowledge about the equipment, allowing them further develop the methodology. Finally, we note that this methodology's applicability extends to industries similar to that of natural gas distribution.

End to End Abstract

Service Assisted Living (SAL): Designing new services for the blood value chain and melanoma

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Service design is a human-centered, creative, iterative approach to the creation of new services, incorporating multidisciplinary contributions, all integrated through design-based methods and tools. Health related services pose specific and specially complex challenges that can benefit from a service design approach. Also, healthcare is a service research priority. In this end-to-end session we will present the contributions of the Service Assisted Living (SAL) Project, both for research and for the society. The SAL project aimed at creating new services to co-create value among multiple stakeholders in two distinct healthcare settings (blood cycle and melanoma). This project involved three organizations, Glintt HS, FEUP and Fraunhofer Portugal. Research contributions included a new interdisciplinary service design method that was recently published in the Journal of Service Research, as well as several conference presentations. For society, this project offered a new service for managing the blood cycle that is being tested in Hospital S. João and a new service to help diagnose skin cancer that is being tested in the ULS Matosinhos, as a well as a prototype for skin cancer follow-up.