Proceedings SOR

Rupnik V. and L. Bogataj (Editors): The 1st Symposium on Operational Research, SOR'93. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1993, 310 pp.

Rupnik V. and M. Bogataj (Editors): The 2nd International Symposium on Operational Research in Slovenia, SOR'94. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1994, 275 pp.

Rupnik V. and M. Bogataj (Editors): The 3rd International Symposium on Operational Research in Slovenia, SOR'95. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1995, 175 pp.

Rupnik V., L. Zadnik Stirn and S. Drobne (Editors.): The 4th International Symposium on Operational Research in Slovenia, SOR'97. Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1997, 366 pp. ISBN 961-6165-05-4.

Rupnik V., L. Zadnik Stirn and S. Drobne (Editors.): The 5th International Symposium on Operational Research SOR '99, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 1999, 300 pp. ISBN 961-6165-08-9.

Lenart L., L. Zadnik Stirn and S. Drobne (Editors.): The 6th International Symposium on Operational Research SOR '01, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2001, 403 pp. ISBN 961-6165-12-7.

Zadnik Stirn L., M. Basti and S. Drobne (Editors): The 7th International Symposium on Operational Research SOR'03, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2003, 424 pp. ISBN 961-6165-15-1.

Zadnik Stirn L. and S. Drobne (Editors): The 8th International Symposium on Operational Research SOR'05, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2005, 426 pp. ISBN 961-6165-20-8.

Zadnik Stirn L. and S. Drobne (Editors): The 9th International Symposium on Operational Research SOR'07, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2007, 460 pp. ISBN 978-961-6165-25-9.

Zadnik Stirn L., J. Žerovnik, S. Drobne and A. Lisec (Editors): The 10th International Symposium on Operational Research SOR'09, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2009, 604 pp. ISBN 978-961-6165-30-3.

Zadnik Stirn L., J. Žerovnik, J. Povh, S. Drobne and A. Lisec (Editors): The 11th International Symposium on Operational Research SOR'11, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2011, 358 pp. ISBN 978-961-6165-35-8.

Zadnik Stirn L., J. Žerovnik, J. Povh, S. Drobne and A. Lisec (Editors): The 12th International Symposium on Operational Research SOR'13, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2013, 390 pp. ISBN 978-961-6165-40-2.

Zadnik Stirn L., J. Žerovnik, M. Kljajić Borštnar, S. Drobne (Editors): The 13th International Symposium on Operational Research SOR'15, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2015, 559 pp. ISBN 978-961-6165-45-7.

Zadnik Stirn L., J. Žerovnik, M. Kljajić Borštnar, S. Drobne (Editors): The 14th International Symposium on Operational Research SOR'17, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2017, 567 pp. ISBN 978-961-6165-50-1.

Zadnik Stirn L., M. Kljajl Borštnar, J. Žerovnik, S. Drobne, J. Povh (Editors): The 15th International Symposium on Operational Research SOR'19, Proceedings. Ljubljana: Slovenian Society Informatika, Section for Operational Research, 2019, 618 pp. ISBN 978-961-6165-55-6.

ISBN 978-961-6165-57-0
9 789616 165570

Proceedings SOR '21

Proceedings of the 16th International Symposium on OPERATIONAL RESEARCH in Slovenia

SOR '21

September 22-24, 2021

Edited by:
S. Drobne • L. Zadnik Stirn • M. Kljajić Borštnar • J. Povh • J. Žerovnik

SOR '21 Proceedings

The 16th International Symposium on Operational Research in Slovenia

September 22 - 24, 2021, Online

Edited by:

S. Drobne, L. Zadnik Stirn, M. Kljajić Borštar, J. Povh and J. Žerovnik

Slovenian Society INFORMATIKA (SDI)
Section for Operational Research (SOR)

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Proceedings of the 16th International Symposium on Operational Research in Slovenia, SOR'21 in Slovenia, September 22 - 24, 2021, Online.

Organiser: Slovenian Society INFORMATIKA – Section for Operational Research, SI-1000 Ljubljana, Litostrojska cesta 54, Slovenia (www.drustvo-informatika.si/sekcije/sor/)

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First published in Slovenia in 2021 by Slovenian Society INFORMATIKA – Section for Operational Research, SI 1000 Ljubljana, Litostrojska cesta 54, Slovenia (www.drustvo-informatika.si/sekcije/sor/)

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

519.8(082)
519.8:005.745(082)
519.81:519.233.3/.5(082)

INTERNATIONAL Symposium on Operational Research in Slovenia (16 ; 2021 ; online)
SOR '21 proceedings : the 16th International Symposium on Operational Research in Slovenia : September 22 - 24, 2021, online / [organiser] Slovenian Society Informatika (SDI), Section for Operational Research (SOR), [co-organiser University of Maribor, Faculty of Organizational Sciences [and] University of Ljubljana, Faculty of Mechanical Engineering] ; edited by S. Drobne ... [et al.]. - Ljubljana : Slovenian Society Informatika, Section for Operational Research, 2021

ISBN 978-961-6165-57-0
COBISS.SI-ID 75727107

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Proceedings of the 16th International Symposium on Operational Research in Slovenia (SOR'21) is cited in: ISI (Index to Scientific & Technical Proceedings on CD-ROM and ISI/ISTP&B online database), Current Mathematical Publications, Mathematical Review, MathSci, Zentralblatt für Mathematic / Mathematics Abstracts, MATH on STN International, CompactMath, INSPEC, Journal of Economic Literature

Technical editor: Samo Drobne
Designed by: Samo Drobne
Printed by: BISTISK d.o.o., Ljubljana, Slovenia
Number of copies printed: 160

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Preface

This volume, Proceedings of the 16th International Symposium on Operational Research, called SOR'21, contains papers presented at SOR'21 (https://sor.fov.um.si/), organised by Slovenian Society INFORMATIKA (SDI), Section for Operational Research (SOR), University of Maribor, Faculty of Organisational Sciences, Kranj, Slovenia (FOV), and University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana, Slovenia (UL FS). The SOR'21 symposium, held 22-24 September 2021, was originally planned to take place in Bled, Slovenia, but was moved online due to the situation of COVID-19 in Slovenia and beyond. The volume contains blind peer-reviewed papers or abstracts of papers presented at the symposium.

The opening address at SOR'21 was given by Prof. Dr. Lidija Zadnik Stirn, President of SOR, Mr. Niko Schlamberger, President of SDI, representatives of FOV and UL FS, Prof. Dr. Mario Jadrić, President of Croatian Operational Research Society (CRORS), Dr Sarah Fores, manager of The Association of European Operational Research Societies (EURO), and presidents/representatives of some others Operational Research Societies from abroad.

SOR'21 is the scientific event in the field of Operational Research, another in the traditional series of biennial international OR conferences organised in Slovenia by SDI-SOR. It is the continuation of fifteen previous symposia. The main objective of SOR'21 is to promote knowledge, interest and education in the field of OR in Slovenia, Europe and worldwide in order to build the intellectual and social capital essential for maintaining the identity of OR, especially at a time when interdisciplinary cooperation is proclaimed as particularly important for solving problems in today's challenging times. By joining IFORS and EURO, the SDI-SOR has also agreed to collaborate with different disciplines, i.e., to balance the depth of theoretical knowledge in OR and the understanding of theory, methods, and problems in other fields within and outside OR. We believe that SOR'21 creates the advantage of these goals, contributes to the quality and reputation of OR by presenting and sharing new developments, opinions and experiences in the theory and practise of OR.

SOR'21 was highlighted by five distinguished keynote speakers. The first part of Proceedings SOR'21 contains invited abstracts, presented by five outstanding scientists: Assist. Prof. Nikolina Ban, University of Innsbruck (UIBK), Department of Atmospheric and Cryospheric Sciences, Innsbruck, Austria, Assist. Prof. Vedran Kojić, University of Zagreb, Faculty of Economics & Business, Zagreb, Croatia, Prof. Panos Patrinos, KU Leuven, Department of Electrical Engineering (ESAT), STADIUS Center for Dynamical Systems, Signal Processing and Data Analytics, Leuven, Belgium, Prof. Suresh P. Sethi, Eugene McDermott Chair Professor of Operations Management, Director, Center of Intelligent Supply Networks, Naveen Jindal School of Management, The University of Texas at Dallas, Dallas, USA, and Prof. Jerneja Žganec Gros, Alpineon Ltd, Ljubljana, Slovenia.

The Proceedings includes 118 papers or abstracts by 240 authors. Most of the authors of the contributed papers came from Slovenia (82), then Croatia (52), Hungary (23), Portugal (23), Serbia (17), Poland (9), Czech Republic (8), Slovak Republic (7), Spain (6), Netherlands (4), Bosnia and Herzegovina (2), Austria (1), Belgium (1), France (1), Germany (1), Romania (1), Ukraine (1), United Kingdom (1), and United States of Amerika (1). The papers published in the Proceedings are divided into Plenary Lectures (5 abstracts), eleven special sessions: Application of Operational Research in Smart Cities (6 papers), Computational Mathematical Optimization (7 papers and 6 abstracts), Data Science – Methodologies and Case Studies (10 papers), Graph Theory and Algorithms (2 papers),

High-Performance Computing and Big Data (3 papers), Industry & Society 5.0: Optimization in Industrial and Human Environments (6 papers), International Projects in Operations Research (2 papers), Lessons Learned from the COVID-19 Pandemic: Applications of Statistical and OR Methods (8 papers), Logistics and Sustainability (9 papers), Operational Research in Ageing Studies and Social Innovations (5 papers), Operations Research in Agricultural Economics and Farm Management (5 papers), and eight sessions: Econometric Models and Statistics (6 papers), Environment and Social Issues (5 papers), Finance and Investments (6 papers), Location and Transport, Graphs and their Applications (5 papers), Mathematical Programming and Optimization (5 papers and 1 abstract), Multi-Criteria Decision-Making (10 papers), Theory of Games (3 papers), and Problems Approaching OR (3 papers).

Proceedings of the previous fifteen International Symposia on Operational Research organised by the Slovenian Section on Operational Research, listed at https://www.drustvo-informatika.si/sekcije/sor/sor-publikacijepublications/, are indexed in the following secondary and tertiary publications: Current Mathematical Publications, Mathematical Review, Zentralblatt fuer Mathematik/ Mathematics Abstracts, MATH on STN International and CompactMath, INSPEC. It is expected that Proceedings SOR'21 will be covered by the same bibliographic databases.

The success of the scientific events at SOR'21 and of the present conference proceedings should be seen because of joint efforts. On behalf of the organisers, we would like to express our sincere gratitude to all those who assisted us in the preparation of the event. Without the dedicated and advice of the active members of the Slovenian Operations Research Section, we would not have been able to attract so many top-class speakers from all over the world. Many thanks to them. In addition, we would like to express our deepest gratitude to the prominent keynote speakers, the members of the Programme and Organising Committees, the reviewers who improved the quality of SOR'21 with their useful suggestions, the section chairs and all the numerous people - far too many to list individually here - who helped in organizing of the 16th International Symposium on Operational Research SOR'21 and compiling this proceedings. Finally, we thank the authors for their efforts in preparing and presenting the papers that made the 16th Symposium on Operational Research SOR'21 a success.

We would like to give special thanks to the Partnership for Advanced Computing in Europe (PRACE) for their financial support.

Ljubljana and Kranj, September 22, 2021

Samo Drobne
Lidija Zadnik Stirn
Mirjana Kljajić Borštnar
Janez Povh
Janez Žerovnik
(Editors)

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URGENT ORDERS IMPACT ON MATERIALS MANAGEMENT IN PORTUGUESE CONSTRUCTION SECTOR - CASE STUDY

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Abstract: The urgent orders could have an impact on construction company performance since affects the organization of the work in the materials warehouse and enhance stress of workers. In this work, the effect of material urgent orders in a Portuguese construction company was analysed. This project consisted of an exploratory study carried out in two phases, the analysis of data and direct observation of the process. The results show that, in this company, there are no-cost impacts on the operations related to logistics, but with urgent requests, the rate of meeting deadlines is lower.

Keywords: Urgent Orders, Materials Management, Construction Sector, Case study.

1 INTRODUCTION

The management of the construction supply chain has a deep effect on success and project expectations in terms of cost, time, and quality, providing a collaborative relationship between suppliers and contractors. The control of the logistics activities is very important since the complexity of the construction supply process will need resources, such as materials, equipment, labour and other services, that need to be available at the right time, in the right amounts and with the desired quality and price.

A good performance on the management of materials and information flows are very important for construction companies since contributes to significant benefits and allow the adding of value for customers. Supply Chain Management (SCM) can be a very useful approach for construction companies since the construction activity is a process characterized by high levels of fragmentation and where the effective integration, coordination, and management of the chain, from suppliers to final clients, is a necessary condition to obtain good results [5].

In the construction sector, a good SCM aims to avoid any risks related to the performance of the company, reducing costs and time, and increasing quality. One important aspect in this supply chain is associated with material flow management, which needs to guarantee the deliveries on time avoiding the delays that could imply urgent orders which could be traduced in increased costs associated with urgent transportation or deliveries after the lead time.

A supply chain is a set of companies that, together, performs the functions of procurement of materials, the transformation of these materials into intermediate and finished goods, and the distribution of these to the consumers. To manage a supply chain positively, it is necessary to reduce lead times and inventory levels, since they contribute to increasing the global cost of the supply chain and reducing customer service. Furthermore, any delays related to a discrepancy between supply and demand may cause an excess of inventories and stock-outs that must be avoided [5]. The procurement process is very important to companies since contributes to improving the performance in product quality, cost, cycle time, and responsiveness [1]. Any construction project uses labour, material, tools, equipment and cash. Material management is the system for planning and controlling to ensure that the right quality and quantity of materials and equipment are specified on time. Materials should be obtained at a reasonable cost and be available for use when needed [6].

In construction projects, changes are very common and possible to occur at any phase of the project. Most changes, if not managed properly will have a considerable impact on the performance of the company as they interrupt work and affect its planned sequence, impacting productivity and accordingly causing schedule delays and cost overrun [3]. Another consequence of project changes is the possibility of urgent orders that could promote an increase in transportation cost, schedule delay and could promote re-work in the materials warehouse. Given this business context, construction companies have increasingly invested in the optimization of their resources, seeking to reduce the duration and costs of projects. What distinguishes supply chains in the construction industry from other industries is the fact that they are temporary, since the location of the works differs from project to project [2]. This factor makes it difficult to standardize the material delivery process, which requires constant reformulation. Building customer loyalty is a way of guaranteeing the company's future, which includes the adoption of effective and efficient logistics.

To analyse the impact that urgent orders may have on the satisfaction of customer orders, the typology of orders placed, the supply chain at the level of processes, the impact that these orders have on the logistics and construction costs, and the best way to fill the situations that lead to urgent orders, should be analysed in order to improve the quality of the services provided.

In this perspective, this research aims to understand the impact of urgent orders in the overall performance of a civil construction company. All the steps considered the specificity of the request, the context in which it is made, the objectives and the urgency of it. Analysing these data, we could assess the impact that the urgent order had on the company's productivity, the response given to the customer and the degree of satisfaction on both sides, because if it is important to satisfy the customer's request, it is equally important to realize the company goals and personal fulfilment of its employees.

In this work, the urgent orders impact on the logistic department in a Portuguese construction company was analysed through a case study, The studied indicators are time, cost and quality related to the materials management process.

The paper is organized as follow: section 2 describes the methods applied, in section 3 the results obtained are discussed and on section 4 the main conclusions are presented.

2 METHODS

To understand the variations that exist concerning the evolution of the civil construction market sector in Portugal, INE was used, more specifically the variable “Number of licensed buildings” in Portugal. This study was carried out from 2010 to 2018 and shows the variation compared to the previous year [4]. Based on Fig. 1, it is noticeable that as of 2015, the market is booming, thus counteracting the crisis it has experienced.

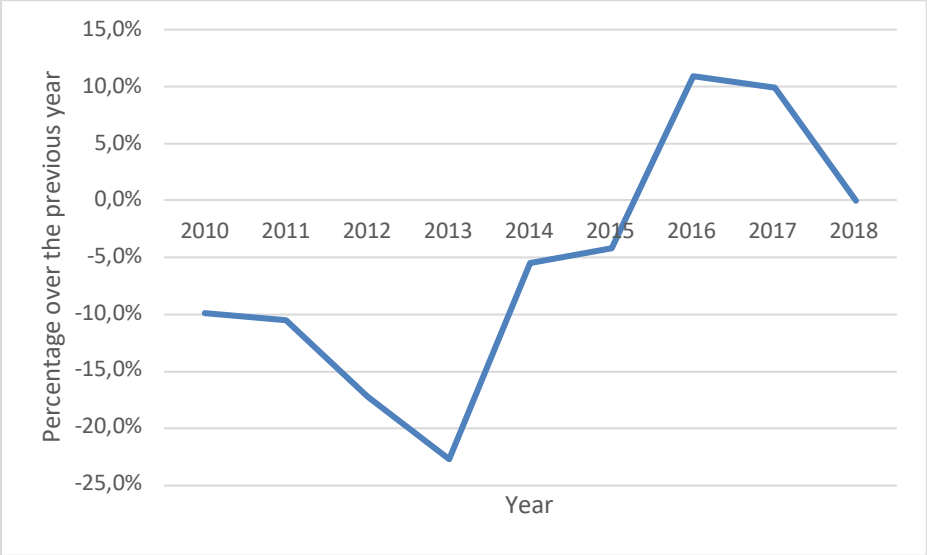

Figure 1: Variation of licence buildings in Portugal

Considering the entire history of the civil construction market in Portugal, the limitations and obstacles occurring in this sector are notorious, evidence of these limitations is the lack of studies and the technological backwardness, which is still experienced today in civil construction, despite that the efforts of the construction companies to overcome this situation are increasingly visible. Urgent orders are an example of possible obstacles that the construction sector faces, being a problem that may affect the normal functioning of the works, compromising delivery times and changing the budgets established at the beginning of each project. In this sector, the customer intends to have the product on time, with excellent quality and at the lowest possible cost. In turn, the company aims to serve its customers well.

As a way of studying the impact of urgent requests on the management of a warehouse of materials, it was important to start by defining its time window, as well as defining what an urgent request is. The time window was defined that the study time corresponds to 4 years of the company's activity, that is, from the beginning of the year 2015 to the end of the year 2018. As an urgent request, a request was considered -what is done less than 3 days in advance.

This project consisted of an exploratory study carried out in two phases, the analysis of data and direct observation of the processes.

2.1 Data Analysis

To carry out this study, it was essential to create and develop a database. In this way and in order to better understand all the phases of its construction, it was divided into 3 phases, as can be seen in Fig. 2.

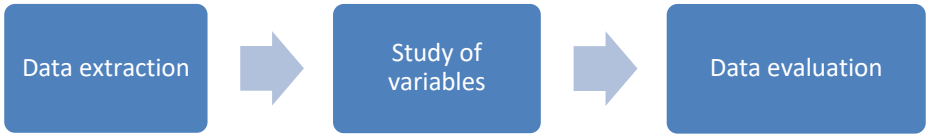

Figure 2: Database processing

Starting with data extraction, this was done using the SAP management software (dstgroup ERP) and occasionally the information from Excel.

After extracting the data, the study of the variables was carried out, that is, all the variables that were contained in SAP and Excel were analysed in detail so that it was possible to later analyse the data. In this last phase, the entire supply chain related to order processing was studied in detail, in other words, the entire process was studied from the moment the material order is placed until its dispatch.

All these processes were carried out to make the database more efficient and thus allowing the best drawing of conclusions. Examples of these same conclusions refer to the study of the typology of requests, the percentage of urgent requests made within the stipulated period, as well as the relationship between this variable and the urgent character, also considering the geographic location of the works and their typology.

In short, it is possible to conclude that through these successive studies the database went from 55,386 lines to 35,232 lines, the latter data being as accurate as possible.

2.2 Direct Observation of Processes

Once the analytical part was completed, and as a way of understanding the process inherent to material management, there was a need to carry out an on-site observation of the warehouse management processes. During this second part of the project, the main objectives were to assess the costs and quality of the service provided, since the rate of meeting deadlines was analysed in the previous point. For a better understanding of the work developed, the following diagram was created to summarise all the steps, Fig. 3.

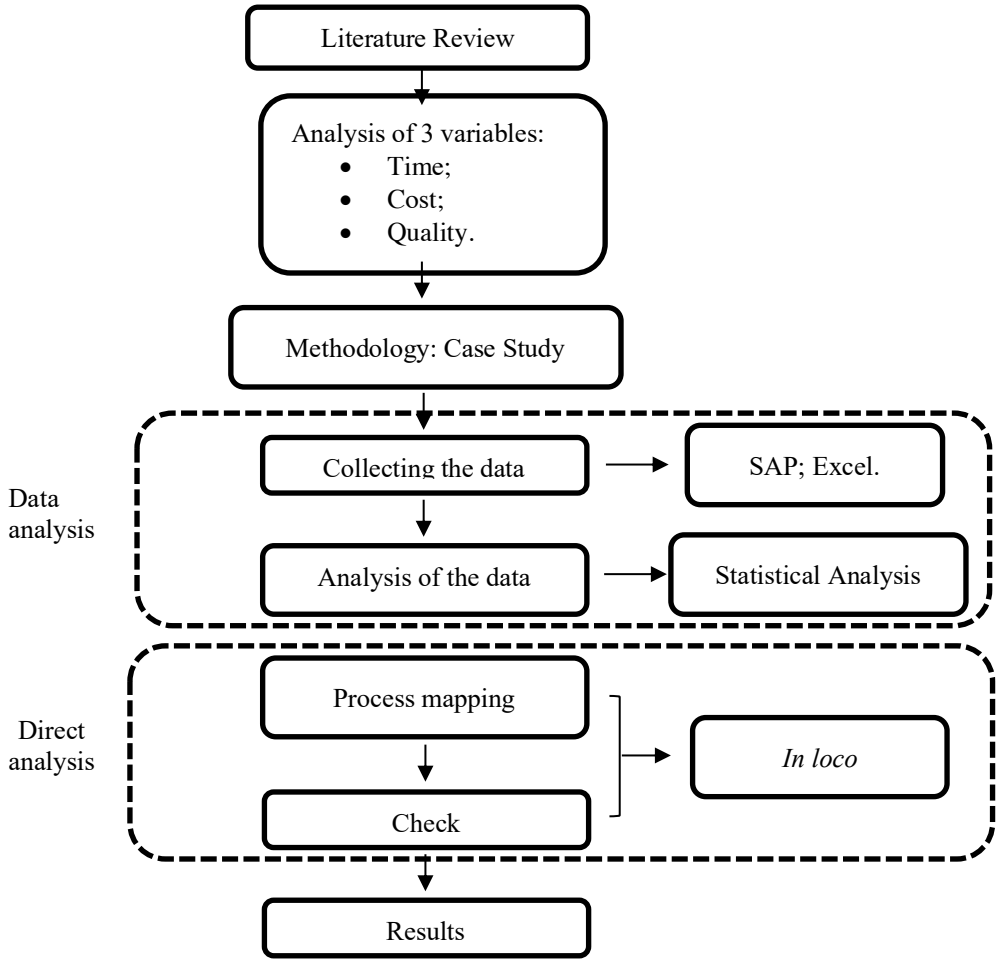

Figure 3: Research process

As for the cost variable, and since the material price is already closed, the only factor that could have an impact on cost would be rework. As rework, the need to redo certain activities was defined due to the occurrence of urgent orders. Regarding the quality variable, the study carried out would analyse how the occurrence of urgent orders could influence non-conformity in orders. The performance of these analyses was based on direct observation of all processes.

To better develop the three pillars of logistics (Time, Cost and Quality), these variables were reorganized to demonstrate a possible way of analysing them. We always focus on the problematic proposal to be studied (see Tab. 1).

Table 1: Variables studied

Time	Cost	Quality
Urgent demand	Product cost	Wrong product
Deadline met	Human resources	Insufficient
	Transport	
	Rework	

It is important to mention that at the beginning of this study urgent demands were thought to have an impact on the logistics department.

3 RESULTS AND DISCUSSION

As previously mentioned, the time window used for the elaboration of this analysis refers to the years 2015-2018. The material families with the most urgent requests were cement (51%), pipes (48%), bricks/blocks (45%), water mains (44%), glass (43%) and sun and wire mesh (41%).

In Tab. 2 it can be observed that the number of orders is increased, and the percentage of urgent orders has fluctuated along the period analysed.

Table 2: Evolution of material orders and urgent orders

Year	Number of material orders	Urgent material orders
2015	7340	34%
2016	8278	42%
2017	8937	34%
2018	10592	29%

For the materials, in the last four years, the probability it requested be urgent is 34% and the probability the deadlines met is 88%. The last probability, how was considered less than was supposed (95%), was a study in particular, in one of the analyses, it is clear in the year 2018, this probability was 92%, very close to the goal. Confronted with this situation, was trying to understand if this situation was punctual or if there is a reason which supports the idea that this will can be continuous, this way it was clear this happens because of the introduction of the request consignment at the material warehouse. The other analysis it was important for analysing the variable time, is the relationship between the type of request (urgent or normal) and the deadlines met, and it was possible to see that when a request is urgent it is less likely to be met than when the request is normal.

For the variable cost, the cost is contractually close, for this reason, the study focused on operations. For this study, all the operations a worker does when processing order was analysed to the extent that we understand when there is rework, being them: (1) Issuing the waybills; (2) When it is necessary to withdraw material that had been separated for another order before; (3)

Checking the order again when there is an urgent demand; (4) Truckloads; Redo the packaging; (5) Phone calls.

After the examination of possible operations, it was understood the only operation, which was a real operation, was the phone call, but in this operation, the cost is insignificant regarding the annual company's annual budget.

Concerning the last variable, quality, the study wasn't exhaustive because there was not enough data and during the time spent with this operation, there were no "problems" because of the occurrence of urgent demands. However, an analysis was carried out as a way to be able to assess the impact that quality could have on the present problem, being studied as follows: (1) Mistakes in the type of material sent; (2) Errors in counts. In the time allotted for this analysis, no non-conformities were resulting from "errors" related to quality.

4 CONCLUSIONS

Although there are no-cost impacts in the operations related to logistics, it is clear that, when it comes to an urgent request, the rate of meeting deadlines is lower, which may have an impact on the costs of the work, so suggests that this fact should be studied in more detail.

By analysing the data provided by the company under study, it was found that urgent orders do not have a great impact on the identified indicators (compliance with deadlines, cost and quality), however, despite the fact that the company has over the years always filled their difficulties and have responded to customer requests, the stress caused by the occurrence of urgent requests is frequent and of little benefit to workers. Although financially there is no direct impact on the company's performance, in human terms, the stress experienced by workers increases in these pressure situations. The main limitation of this project are related with the data treatment.

Acknowledgement

This work has been supported by FCT within the R&D Units Project Scope UIDB/00319/2020 (ALGORITMI).

References

[1]. Álvarez, E. Díaz, F. 2011. Collaboration and Exceptions Management in the Supply Chain. In Supply Chain Management - New Perspectives: 143-166.

[2]. Anees, M.M., Mohamed, H.E., Razek, M.E.A. 2013. Evaluation of change management efficiency of construction contractors. Housing and Building National Research Center, 9: 77-85.

[3]. Donyavi, S. and Flanagan, R. 2009. The impact of effective material management on construction site performance for small and medium sized construction enterprises. Procs 25th Annual ARCOM Conference, Nottingham, UK, Association of Researchers in Construction Management: 11-20.

[4]. Instituto Nacional de Estatística (INE). Retrieved September, 4 (2019), from https://eportugal.gov.pt/entidades/instituto-nacional-de-estatistica.

[5]. Serpell, A, Heredia, B. 2004. Supply chain management in construction: diagnosis and application issues. International Symposium on Globalisation and Construction, Rotterdam: 455-466.

[6]. Vrijhoef, R., Koskela, L. 2000. The four roles of supply chain management in construction. European Journal of Purchasing & Supply Management, 6: 169-178.