Proceedings of the 2020 Winter Simulation Conference
K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.

ON THE USE OF SIMULATION-OPTIMIZATION IN SUSTAINABILITY AWARE PROJECT PORTFOLIO MANAGEMENT

Miguel Saiz
Marisa Andrea Lostumbo

Universitat Oberta de Catalunya
IN3 – Computer Science Department
Av. Carl Friedrich Gauss 5
Castelldefels, 08860, SPAIN

Angel A. Juan

Universitat Oberta de Catalunya
Euncet Business School
Av. Carl Friedrich Gauss 5
Castelldefels, 08860, SPAIN

David Lopez-Lopez

ESADE Business School
General Management & Strategy Department
Avda. Pedralbes, 60-62
Barcelona, 08034, SPAIN

ABSTRACT

Among other variables, uncertainty and limitation of resources make real-life project portfolio management a complex activity. Simulation-optimization is considered an appropriate technique to face stochastic problems like this one. The main objective of this paper is to develop a hybrid model, which combines optimization with Monte Carlo simulation, to deal with stochastic project portfolio management. A series of computational experiments illustrate how these hybrid approach can include uncertainty into the model, and how this is an essential contribution for informed decision making. A relevant novelty is the inclusion of a sustainability dimension, which allows managers to select and prioritize projects not only based on their monetary profitability but also taking into account the associated environmental and/or social impact. This additional criterion can be necessary when evaluating projects in areas such as civil engineering, building and construction, or urban transformation.

1 INTRODUCTION

Changing project priorities within an organization may be a sign of poor project portfolio management (PPM). Even with the large number of results reflected in the scientific literature of this problem, practitioners are still demanding PPM methods that reduce the probability of error in the selection and prioritization of the projects that compose the portfolio. According to Mohagheghi et al. (2019) some authors focus on improving the interaction with decision makers, while others concentrate on providing better solutions in reduced computing times by employing metaheuristic algorithms and the combination of simulation techniques and/or fuzzy sets with metaheuristic algorithms. Actually, one of the main trends in PPM is the combination of optimization-simulation and machine learning approaches. Simulation-optimization becomes a valuable tool to face practical problems including random variables, such as planning under uncertainty, estimating the reliability of complex configurations (Faulin et al. 2008), or including behavioral analysis into project portfolio selection.

This paper first reviews recent contributions to PPM based on simulation and optimization methods and using software tools that are popular in business-oriented applications, such as the well-known @Risk software by Palisade. Then, the paper identifies and define a portfolio selection criteria that considers the monetary and the sustainability dimensions. As a result, an original model is developed to support decisions makers while managing uncertainty in project portfolio selection and prioritization. A computational case study contributes to illustrate the main ideas behind our model. The rest of the paper is structured as follows: Section 2 offers a review on related work. Section 3 discusses the importance of considering sustainability issues in project portfolio management. Section 4 proposes a simulation-optimization model implemented in the @Risk Optimizer functionality, and analyzes a first round of experiments computed with this initial model. Section 5 provides an enriched model in which the probability distributions have been properly selected using more data; the new model also considers two objectives: monetary efficiency and sustainability. Section 6 includes some managerial insights that can be derived from the computational experiments. Finally, in Section 7 we highlight the main findings of this work and propose some promising research lines.

2 RELATED WORK ON PROJECT PORTFOLIO MANAGEMENT

The problem of selecting and prioritizing projects in the portfolio has been extensively addressed in the literature. Anell (2000) indicates that managers have to systematically analyze and evaluate projects in order to ensure that they fit and conform with the appropriate company portfolio, discarding projects that are no longer adequate or lose importance. In order to do that, managers need to analyze different aspects that influence projects over the portfolio timeline. More recently, Lopes and de Almeida (2015) identify three key aspects in project selection: *(i)* the multi-objective nature of the decision context; *(ii)* an assessment of the projects synergies; and *(iii)* the influence the previous aspects have on the decision maker's preference structure. Hence, the combination of these aspects results in a multi-attribute decision model. Defining the project portfolio is also related to the corporate strategy and the limitation of resources. Recent surveys on the use of metaheuristic algorithms in project portfolio optimization and related topics can be found in Soler-Dominguez et al. (2017) and Doering et al. (2019).

There is a need for addressing the optimization of the project portfolio at risk (with an effective use of limited resources), using techniques such as an stochastic optimization and Monte Carlo simulation. Actually, simulation-based optimization approaches are applied in several works related to project portfolio selection. Thus, for instance, Subramanian et al. (2003) combine mathematical programming and discrete-event simulation to obtain statistically significant improvements over previous approaches. Also, Subramanian et al. (2001) combine both methodologies to assess the uncertainty and control the risk. In a more recent work, Wood (2016) defines a risk aversion factor in order to capture portfolio value and risk in a single metric. Kettunen and Salo (2017) use Monte Carlo simulation in the project selection decision to avoid inaccurate risk estimations in the project portfolio. Identifying the best values for a set of variables in decision making falls within the scope of optimization. However, as pointed out by Better and Glover (2006), the methods available for finding optimal decisions –including stochastic optimization– have not effectively addressed the complexity and uncertainty posed by real-world problems. Hence, the combination of simulation with metaheuristics (simheuristics) seems to be one of the most promising methodologies to deal with these real-life stochastic optimization problems (Juan et al. 2018; Panadero et al. 2020).

3 SUSTAINABLE PROJECT PORTFOLIO MANAGEMENT

In a recent review on project portfolio selection, Mohagheghi et al. (2019) conclude that social and environmental criteria should also be considered while selecting a project portfolio. Hence, these authors propose dimensions such as sustainability, resiliency, foreign investment, and exchange rates to be considered into the project portfolio selection process. They focus on artificial intelligence environments using big data and fuzzy stochastic optimization techniques. In a similar direction, Sabini (2018) identifies a strong connection between sustainability and project management. In addition, the author identifies new parties, such as Green Project Management (https://www.greenprojectmanagement.org/) or the United Nations Office for Project Services (https://www.unops.org/), which are also contributing to make projects more sustainable. Given the importance and impact that projects have on society, organizations will experience an increasing pressure to balance social, environmental, and economic interests in their projects. Sanchez (2015) reinforces this trend by maintaining that more and more organizations embrace sustainability through their mission and strategy, although the social and environmental dimensions of sustainability are difficult to incorporate into portfolios, programs, and projects. The author argues that the portfolio of projects requires selecting the best combination of projects based on the simultaneous analysis of the environmental impact of the projects and the achievement of the strategic objectives of the organization.

Facing the global growing environmental conscientiousness, Xidonas et al. (2016) propose the exploitation of sustainable patterns and incorporate the energy and environmental corporate responsibility (EECR) in decision making. The authors propose a bi-objective programming model in order to provide the Pareto set of optimal portfolios based on the net present value of projects and the EECR score of firms. In their research, they combine Monte Carlo simulation and multi-objective programming in order to deal with the inherent uncertainty affecting the objective functions' coefficients. Yang et al. (2016) incorporate the carbon footprint to solve strategic decision making under resource constraints by proposing the connection between activity-based costing evaluation and carbon footprint. This is also the case of Echeverria et al. (2014), who noticed that many governments and international agencies propose policies aimed at reducing greenhouse gas emissions, being one of these initiatives the carbon footprint (https://www.carbonfootprint.com/). According to these authors, knowing the carbon footprint of a product –or project in our case–, can contribute to the reduction of their carbon footprint and, hence, to be become a more competitive item in a market increasingly sensitive to the sustainability dimension. These authors also introduce the concept of 'willingness to pay' for a product in compensation for its sustainability impact. Our approach combines simulation and optimization with a willingness-to.pay analysis in the selection and prioritization of projects.

Fu et al. (2005) provides a general overview of the primary approaches founded in the research literature for carrying out simulation optimization. The authors survey some of the commercial software market available for simulation, and summarize their search strategies. Among these, the RISK Optimizer Software (https://www.palisade.com/risk/default.asp) includes genetic algorithms (GA) as its primary strategy for searching potentially optimal strategies. A project portfolio optimization problem can be addressed by using the RISK GA in combination with the Monte Carlo simulation engine also included in this piece of software.

4 INITIAL COMPUTATIONAL EXPERIMENTS

We consider a case example based on existing and ongoing smart-mobility initiatives in the area of Barcelona (Spain). In order to collect the experimental data, different reports published by several City Councils in the metropolitan area of Barcelona have been analyzed. The focus of this analysis was on the the relationship between the willingness-to-pay and the CO_2 values associated with different smart-mobility initiatives. Our professional experience in the sector of technological projects, in addition to the information obtained from the public sources, has allowed us to establish an order of magnitude associated with the background in the private and public industry and the parameters defined for each candidate project (Table 1). The optimization problem consists in selecting the portfolio of projects that maximizes two conflicting targets, savings in carbon footprint and citizens' willingness to pay for the improved services, while respecting budget and human resources constraints.

Let us assume that the city project portfolio has two types of projects. Firstly, basic or essential projects, which must be executed without doubt. Examples of these projects could be infrastructure maintenance. Secondly, not essential projects, which could be postponed to the next period of implementation.

A data analysis software (@Risk in our case) can be used to study the data associated with the willingness-to-pay and CO_2 values. In particular, the following goals and constraints have been considered: *(i)* to maximize the willingness-to-pay; *(ii)* to maximize the total savings in CO_2 emissions; and *(iii)* to achieved the former goals without violating the budget and human resources constraints.

The data we use on the simulation is based on the following parameters:

- A total of 15 candidate projects on smart mobility.
- Each project requires a known budget and a workload to be assumed by the human resources, determined as working weeks.
- A 6-month planning period is considered.
- The price increase that each citizen would accept to enjoy the project benefits, also known as willingness-to-pay, has been obtained after a survey.
- The reduced carbon footprint (emission savings, in millions of tons of CO_2) is also know for each project.

Table 1 contains the expected values associated with each candidate project. Actually, these expected values correspond to random variables, each of them following a probability distribution (more details will be given later).

Table 1: Expected values for the candidate projects.

Project #	**Human resources [Working-weeks]**	**Capital [k$]**	**Willingness to pay [$ per hab & yr.]**	**Emission savings [Tm CO_2]**
1	200	229	59	34
2	95	173	36	72
3	200	120	52	36
4	50	77	7	240
5	40	71	5	244
6	145	146	42	72
7	100	104	30	116
8	180	179	53	38
9	130	45	24	134
10	180	182	98	18
11	150	120	47	74
12	105	81	34	120
13	180	124	53	42
14	140	64	24	138
15	220	216	98	22

Initially, we will assume a 'low-level' information scenario in which the probability distributions that model each of the previous variables are uniform ones. For computational purposes, as one working year represents 44 weeks, then the 6-month planning period includes a total of 22 weeks. Figure 1 shows the four histograms representing the distribution of each of the four project parameters related to Project 1, where 200 working weeks can be assumed within the period (22 weeks) by for example 200/22 = 9 full-time workers.

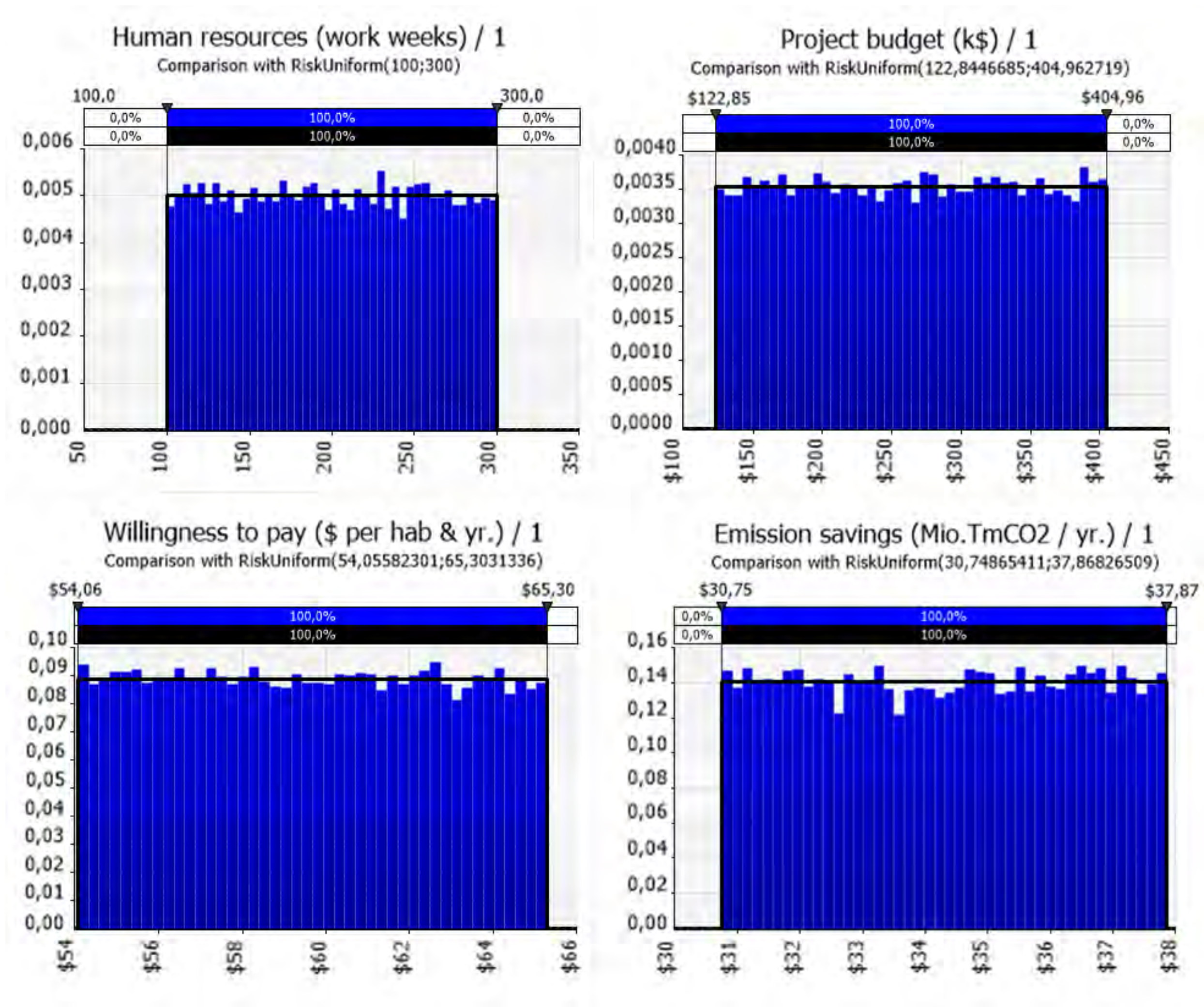

Figure 1: Low level of information, uniform probability distribution.

Not all the 15 candidate projects can be selected within the available budget, which is set to 900 k$ and $1,100$ working weeks. To represent the optimization model of the problem, the following decision variables have been considered:

- a = "available number of working-weeks".
- b = "available budget".
- WTP = "willingness to pay".
- CO_2 = "amount saved in emissions".

To carry out the simulation, the following restrictions have been considered in our model:

- 1,100 working weeks (in this example we considered that only 50 full time employees can be dedicated to these project during the 22 week planning period).
- A maximum budget of 900,000 euros.
- The portfolio choice must achieve a utilization of the available human resources of at least 95%.

In order to identify the efficient frontier, we need to determine the range in which we want to perform the analysis. For that, we need to solve two stochastic optimization problems. Firstly, the maximum willingness-to-pay that is achievable within the budgetary and human resource constraints. Secondly, the maximum emission savings achievable within the same constraints. Figure 2 (left) shows the answer to the first question. It corresponds to the choice of projects 3, 10, 12, and 15. The mean value that results is \$287. This optimal level has been achieved at the expense of low levels in emission reduction (averaging 200 Mio.Ton per yr., as displayed in Figure 2 (right).

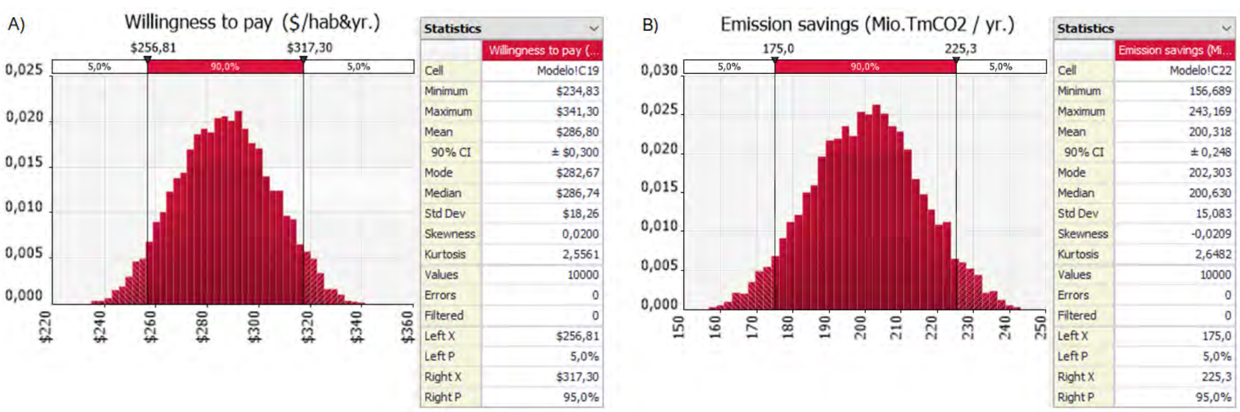

Figure 2: Histogram of outcomes in terms of willingness-to-pay, maximizing their mean value.

The maximum emission reduction level achievable within the same constraints is depicted on Figure 3 (left). It corresponds to the choice of projects 4, 5, 7, 9, 11, 12, and 14. Its mean is $1,082$ Mio.Ton per yr. This optimal emission reduction is achievable at the expense of lower willingness-to-pay levels, with an average of \$174 as shown in Figure 3 (right). Knowing the ranges for the two objectives, we can now complete the frontier analysis. The result is the one summarized in Figures 4 and 5.

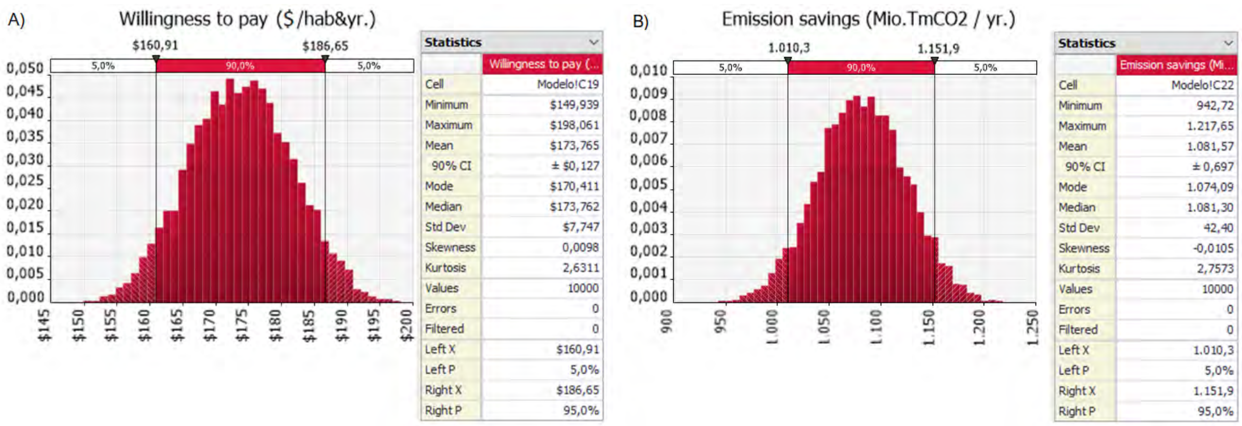

Figure 3: Histogram of outcomes in terms of emission reduction levels, maximizing their mean value.

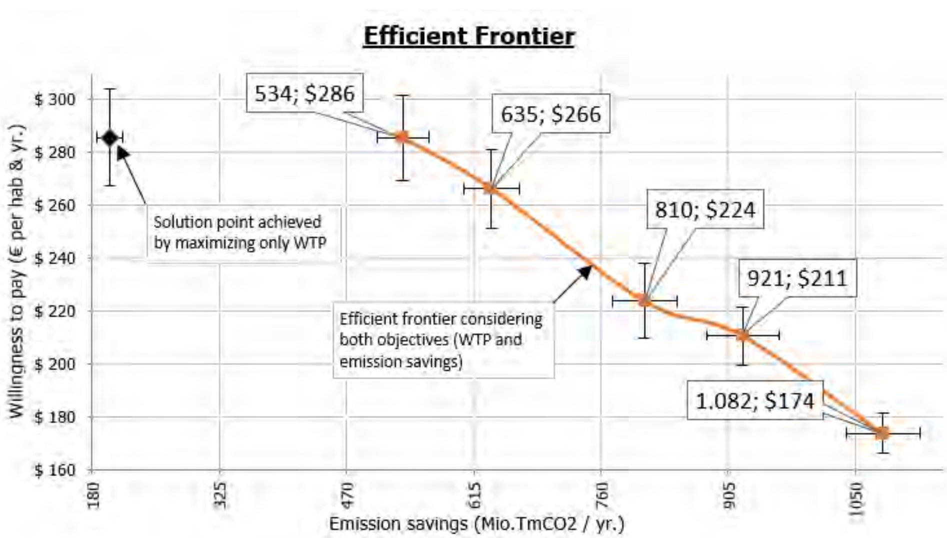

Figure 4: Efficient frontier of portfolios.

Emission savings (Mio.TmCO2 / yr.)	Willingness to pay ($ per hab & yr.)	Selected projects 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
534	$286	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
635	$266	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0
810	$224	0	0	1	1	1	0	0	0	0	1	0	1	0	1	0
921	$211	0	0	1	1	1	1	0	0	1	0	0	0	1	1	0
1.082	$174	0	0	0	1	1	0	1	0	1	0	1	1	0	1	0

Figure 5: Portfolio combinations for each point within the efficient frontier.

5 IMPROVEMENT OF PORTFOLIO OPTIONS THROUGH BETTER RISK MODELLING

The uniform distributions employed in the previous section represent a scenario with limited information. In order to illustrate the benefits of having more information on how each of the random variables are distributed, we will now assume that more observations are available and that we have been able to fit these observations by a proper probability distribution. Accordingly, the project budget has been modeled using a gamma distribution. This distribution has been chosen due to its adequacy to simulate the tail risks, which are typical in many projects. In order to have comparable orders of magnitude, percentiles 5% and 95% of each project have been forced to match the maximum and minimum limits of the range estimated for the associated project in the previous section. The willingness-to-pay and the emission savings variables have been modeled using a subjective beta probability distribution, as in Yoe (2011). According to the previous reference, it is possible to consider the truncated beta distribution to eliminate cases of extreme values, since they are very unrealistic.

As before, their percentiles 5% and 95% have been forced to match the lower and upper limits assigned to each project. Likewise, human resources have been modeled through beta distributions, applying the same conditions to the extreme percentiles as before. This is more optimistic than the previous cases, which reflects the fact that the resource dispersion can typically be more controlled than the project benefits or project budget. Figure 6 illustrates the graphical representation of these probability distributions ("improved model") compared to the previous ones ("rough model") in Figure 1. Repeating the steps explained in Section 4, a new efficient frontier is obtained (Figure 8). Notice that it shows a larger set of portfolio proposals, which contributes to diversify risk. It becomes clear that the effort in getting a better description of the potential benefits allows to include more projects in the portfolio, and also to obtain higher benefits without increasing the probability of exceeding the budget or human resource constraints.

6 MANAGERIAL INSIGHTS

Computing the net present value of a project portfolio constitutes one of the most popular selection criterion. Hence, the goal is to maximize the monetary value of the portfolio. In addition, our method aims to maximize both the portfolio value (modeled as willingness to pay) and the level of emission savings. However, environmental and sustainability challenges request to take these dimensions into account when designing a portfolio of projects, especially in areas such as civil engineering, infrastructure networks, and urban logistics and transportation systems. Accordingly, managerial decisions need to reconcile two objectives, which in some cases may be conflicting with each other. This is typically the case for projects in the public sector, where there is a need for economic efficiency but also a requirement for reducing the

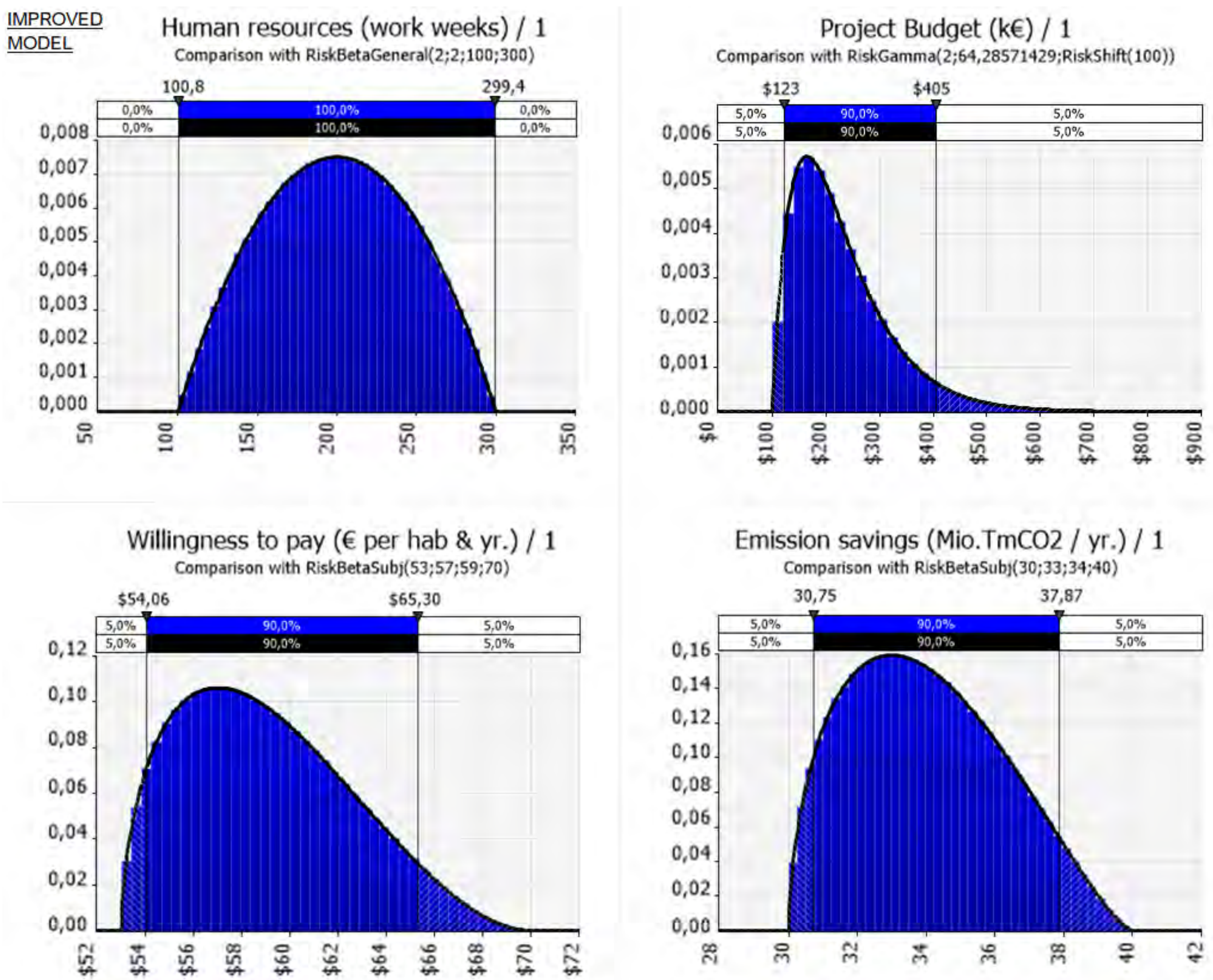

Figure 6: Distribution comparison of the new model respect to the previous one.

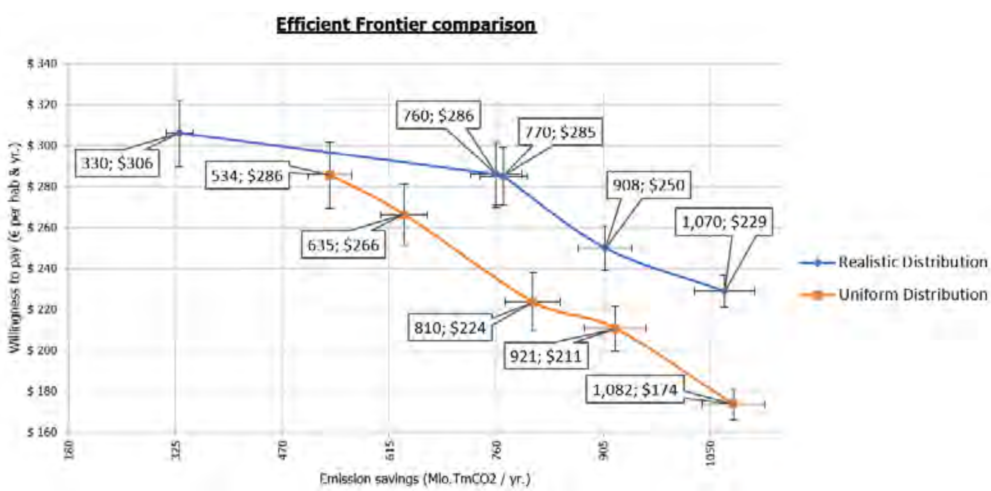

Figure 7: Efficient frontier of portfolios.

ROUGH MODEL

Selected projects

Emission savings (Mio.TmCO2 / yr.)	Willingness to pay (€per hab & yr.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
534	$286	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0
635	$266	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0
810	$224	0	0	1	1	1	0	0	0	0	1	0	1	0	1	0
921	$211	0	0	1	1	1	1	0	0	1	0	0	0	1	1	0
1.082	$174	0	0	0	1	1	0	1	0	1	0	1	1	0	1	0

IMPROVED MODEL

Selected projects

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
242	$292	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0
760	$286	0	0	1	1	0	0	0	0	1	1	1	1	0	1	0
770	$285	0	0	0	0	1	0	0	0	1	1	1	1	1	1	0
908	$250	0	0	1	1	1	0	1	0	1	1	0	1	0	0	0
1.070	$229	0	0	1	1	1	0	1	0	1	0	0	1	1	1	0

Figure 8: Improved optimal portfolio selection.

carbon footprint. The combination of simulation with optimization offers a valuable tool to support these complex decision-making processes.

The advantages of applying a bi-objective approach instead of a single-objective one can be clearly observed in Figure 4: with a very similar level of average willingness-to-pay ($286), it is possible to choose a portfolio configuration that leads to a savings of 543 million-tons of CO_2 instead of the original 200 that were identified in the single-objective scenario. In addition, we have illustrated the importance of modeling each project in a way as realistic as possible –i.e., by using the proper probability distribution to model each random variable. This has been observed in the case study, where an improvement of 25% (for the same level of willingness-to-pay) was reached. Some final insights obtained from our experiments are:

- By including the willingness-to-pay variable, it is possible to identify a project portfolio that is not only selected based on the citizen-perceived value, but also according to a sustainability factor.
- In most real-life projects, it is extremely difficult to identify a single portfolio as “the best portfolio”. Instead, it is usually the case that trade-offs exist between the portfolio monetary cost and the environmental cost.
- A holistic model, like the one presented here, allows managers to make more informed decisions based on several criteria.

7 CONCLUSIONS

For the project portfolio optimization problem with sustainability issues, this paper has introduced a simulation-optimization methodology that is able to generate a Pareto curve showing balanced portfolio configurations. This approach allows then offer efficient take-rates in the share among two conflicting objectives, i.e., monetary return and environmental or social sustainability. It has also become evident that one-dimensional portfolio optimization is very likely to hide other possible options, which can add value for most stakeholders at a relatively low monetary cost.

In the same way, a more realistic and thorough estimation of the possible project outcomes and needs (human and economical resources), is leading to a portfolio choice that offers better average values. As future research lines, the following ones can be considered: *(i)* extension of this methodology and case analysis to more than two objectives; *(ii)* development of a complete simheuristic approach independent from any commercial software; and *(iii)* development of a real-life case study to evaluate how the different alternatives would be perceived by managers in different sectors, and how they influence their decisions.

ACKNOWLEDGEMENTS

This work has been partially funded by the IoF2020 project of the European Union (grant agreement no. 731884) and by the Erasmus+ Program (2018-1-ES01-KA103-049767).

REFERENCES

Anell, B. 2000. "Managing Project Portfolios". In *Projects as Business Constituents and Guiding Motives*, edited by R. A. Lundin and F. Hartman, 77–88. Boston, MA: Springer US.

Better, M., and F. Glover. 2006. "Selecting Project Portfolios by Optimizing Simulations". *The Engineering Economist* 51(2):81–97.

Doering, J., R. Kizys, A. A. Juan, A. Fito, and O. Polat. 2019. "Metaheuristics for Rich Portfolio Optimisation and Risk Management: Current State and Future Trends". *Operations Research Perspectives* 2019:100121.

Echeverria, R., V. H. Moreira, C. Sepúlveda, and C. Wittwer. 2014. "Willingness to Pay for Carbon Footprint on Foods". *British Food Journal* 116(2):186–196.

Faulin, J., A. A. Juan, C. Serrat, and V. Bargueno. 2008. "Predicting availability functions in time-dependent complex systems with SAEDES simulation algorithms". *Reliability Engineering & System Safety* 93(11):1761–1771.

Fu, M. C., F. W. Glover, and J. April. 2005. "Simulation Optimization: a Review, new Developments, and Applications". In *Proceedings of the 2005 Winter Simulation Conference*, edited by M. E. Kuhl, N. M. Steiger, F. B. Armstrong, and J. A. Joines, 83–95. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Juan, A. A., W. D. Kelton, C. S. Currie, and J. Faulin. 2018. "Simheuristics Applications: Dealing with Uncertainty in Logistics, Transportation, and other Supply Chain Areas". In *Proceedings of the 2018 Winter Simulation Conference*, edited by M. Rabe, A. A. Juan, N. Mustafee, A. Skoogh, S. Jain, and B. Johansson, 3048–3059. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

Kettunen, J., and A. Salo. 2017. "Estimation of Downside Risks in Project Portfolio Selection". *Production and Operations Management* 26(10):1839–1853.

Lopes, Y. G., and A. T. de Almeida. 2015. "Assessment of Synergies for Selecting a Project Portfolio in the Petroleum Industry based on a Multi-Attribute Utility Function". *Journal of Petroleum Science and Engineering* 126:131–140.

Mohagheghi, V., S. M. Mousavi, J. Antuchevičienė, and M. Mojtahedi. 2019. "Project Portfolio Selection Problems: a Review of Models, Uncertainty Approaches, Solution Techniques, and Case Studies". *Technological and Economic Development of Economy* 25(6):1380–1412.

Panadero, J., J. Doering, R. Kizys, A. A. Juan, and A. Fito. 2020. "A Variable Neighborhood Search Simheuristic for Project Portfolio Selection under Uncertainty". *Journal of Heuristics* 26:353–375.

Sabini, L. 2018. "Integrating Sustainability into Project Management Practices: the Perspective of Professional Institutions". *International Research Network on Organizing by Projects* 2017:1–17.

Sanchez, M. A. 2015. "Integrating Sustainability Issues into Project Management". *Journal of Cleaner Production* 96:319–330.

Soler-Dominguez, A., A. A. Juan, and R. Kizys. 2017. "A Survey on Financial Applications of Metaheuristics". *ACM Computing Surveys (CSUR)* 50(1):15:1–15:23.

Subramanian, D., J. F. Pekny, and G. V. Reklaitis. 2001. "A Simulation-Optimization Framework for Research and Development Pipeline Management". *AIChE Journal* 47(10):2226–2242.

Subramanian, D., J. F. Pekny, G. V. Reklaitis, and G. E. Blau. 2003. "Simulation-Optimization Framework for Stochastic Optimization of R&D Pipeline Management". *AIChE Journal* 49(1):96–112.

Wood, D. A. 2016. "Asset Portfolio Multi-Objective Optimization Tools provide Insight to Value, Risk and Strategy for Gas and Oil Decision Makers". *Journal of Natural Gas Science and Engineering* 33:196–216.

Xidonas, P., H. Doukas, G. Mavrotas, and O. Pechak. 2016. "Environmental Corporate Responsibility for Investments Evaluation: an Alternative Multi-Objective Programming Model". *Annals of Operations Research* 247(2):395–413.

Yang, C.-H., K.-C. Lee, and H.-C. Chen. 2016. "Incorporating Carbon Rootprint with Activity-based Costing Constraints into Sustainable Public Transport Infrastructure Project Decisions". *Journal of Cleaner Production* 133:1154–1166.

Yoe, C. 2011. *Principles of Risk Analysis: Decision Making under Uncertainty*. Boca Raton, Florida: CRC press.

AUTHOR BIOGRAPHIES

MIGUEL SAIZ is Lecturer of Project Management at the Operations & Data Science Department of the EAE Business School (Spain) and Researcher at IN3 - Computer Science Department of Universitat Oberta de Catalunya. He holds a MEng from Universidad de Navarra and a MBA from ESADE Business School. He has founded a consultancy firm in project management, partnering with one of the Big Five tech companies, deploying a portfolio management tool at several enterprises. His email address is msaizgarcia@uoc.edu.

MARISA ANDREA LOSTUMBO is Lecturer of Project Management at the Operations & Data Science Department of the EAE Business School (Spain) and Researcher at IN3 - Computer Science Department of Universitat Oberta de Catalunya. She holds a Bachelor of Architecture and a M.Sc. in Project Management. Her research interests include simulation and optimization methods in project management. She is a senior consultant and in-company trainer in project management processes and procedures. Her email address is marisa.andrea.lostumbo@campus.eae.es.

ANGEL A. JUAN is a Full Professor of Operations Research & Industrial Engineering in the Computer Science Department at the Universitat Oberta de Catalunya (Barcelona, Spain). He is also the Director of the ICSO research group at the Internet Interdisciplinary Institute and Lecturer at the Euncet Business School. Dr. Juan holds a Ph.D. in Industrial Engineering and an M.Sc. in Mathematics. He completed a predoctoral internship at Harvard University and postdoctoral internships at Massachusetts Institute of Technology and Georgia Institute of Technology. His main research interests include applications of simheuristics and learnheuristics in computational logistics and finance, as well as mathematical e-learning. He has published about 100 articles in JCR-indexed journals and over 215 papers indexed in Scopus. His website address is http://ajuanp.wordpress.com and his email address is ajuanp@uoc.edu.

DAVID LOPEZ-LOPEZ is a Lecturer at ESADE Business School (Spain). He holds a PhD in Digital Transformation, and a joint MBA from ESADE and Duke University (USA). He is also an entrepreneur and investor in the digital sector. He has founded a digital consulting firm that employs more than 180 people and has participated and advised 8 hi-tech start-ups. He has published more than 15 articles in journals and conference proceedings. His email es david.lopez1@esade.edu.