

# Contents

Abstract	v
Resumen	vii
Resum	ix
Contents	xi
Chapter I: Introduction	2
1 Context and supporting institutions . . . . .	2
2 Background . . . . .	3
3 Objectives . . . . .	6
4 Methodology . . . . .	7
5 Structure of the dissertation . . . . .	8
Bibliography . . . . .	14
Chapter II: A review of mathematical models for supporting the order promising process under Lack of Homogeneity in Product and other sources of uncertainty	17
1 Introduction . . . . .	18
2 LHP inherent characteristics . . . . .	21
3 Literature review methodology . . . . .	23
4 Structural dimensions for the review . . . . .	25
4.1 Environment . . . . .	26

4.2 LHP/uncertainty modelling . . . . .	26
4.3 Customer orders . . . . .	27
4.4 Order promising . . . . .	28
4.5 Model characteristics . . . . .	29
5 Material evaluation . . . . .	29
5.1 Environment . . . . .	30
5.1.1 Sector . . . . .	31
5.1.2 Supply chain physical scope . . . . .	31
5.1.3 Manufacturing strategy . . . . .	32
5.1.4 Findings . . . . .	33
5.2 LHP/uncertainty modelling . . . . .	33
5.2.1 Modelling inherent LHP characteristics . . . . .	35
5.2.2 Uncertainty modelling . . . . .	37
5.2.3 Findings . . . . .	41
5.3 Customer orders . . . . .	41
5.3.1 Order lines . . . . .	41
5.3.2 Homogeneity requirements . . . . .	41
5.3.3 Flexibility in requirements . . . . .	42
5.3.4 Findings . . . . .	45
5.4 Order promising . . . . .	45
5.4.1 Allocation rules . . . . .	45
5.4.2 Execution mode . . . . .	46
5.4.3 Availability levels . . . . .	49
5.4.4 Findings . . . . .	49
5.5 Model characteristics . . . . .	49
5.5.1 Purpose . . . . .	50
5.5.2 Validation method . . . . .	51
5.5.3 Modelling approach . . . . .	52
5.5.4 Novelty . . . . .	54
5.5.5 Findings . . . . .	54
6 Conclusions. Identifying areas for further research . . . . .	59
7 Publication data . . . . .	62
Bibliography . . . . .	63

Chapter III: A Fuzzy Order Promising Model With Non Uniform Finished Goods 71

1 Introduction . . . . .	72
--------------------------	----

2 Related work . . . . .	74
3 The FMILP-ATP-LHP Model . . . . .	76
3.1 Description of the problem . . . . .	76
3.2 Assumptions . . . . .	77
3.3 Notation . . . . .	78
3.4 Model formulation . . . . .	80
4 Solution methodology . . . . .	83
4.1 Transforming the FMILP-ATP-LHP model into an equivalent $\alpha$ -parametric crisp model . . . . .	83
4.2 Methodology for alpha level evaluation based on fuzzy TOPSIS . . . . .	85
5 Experimental design . . . . .	90
5.1 Data . . . . .	90
5.2 Evaluation of Deterministic and Fuzzy Decisions: Experimental Methodology . . . . .	91
5.3 Application of the experimental methodology . . . . .	93
5.3.1 Alpha evaluation for the FMILP-ATP-LHP model . . . . .	93
5.3.2 Evaluating the Deterministic and Fuzzy Solutions . . . . .	98
6 conclusions . . . . .	100
7 Publication data . . . . .	102
Bibliography . . . . .	103

Chapter IV: A fuzzy model for shortage planning under uncertainty due to lack of homogeneity in planned production lots 109

1 Introduction . . . . .	110
2 Shortage planning problem characteristics . . . . .	114
3 Fuzzy shortage planning LHP model formulation . . . . .	118
3.1 Nomenclature . . . . .	118
3.2 Objective . . . . .	118
3.3 Constraints . . . . .	118
4 Solution methodology for the LHP fuzzy shortage planning model . . . . .	124
4.1 Transforming the fuzzy mixed-integer linear programming model into an equivalent crisp model . . . . .	124
4.2 The equivalent auxiliary crisp LHP-FSP model . . . . .	128
4.3 Methodology for final solution selection . . . . .	129
5 Computational experiments: application to a ceramic tile company . . . . .	130
5.1 Problem data description . . . . .	131

5.2 Generation of scenarios . . . . .	133
5.3 Experimental results . . . . .	135
5.4 Selecting the final solution to be implemented . . . . .	138
6 Conclusions . . . . .	140
7 Publication data . . . . .	141
Bibliography . . . . .	142

Chapter V: Modelling pricing policy based on shelf-life of non homogeneous Available-To-Promise in fruit supply chains 150

1 Introduction. . . . .	151
2 Related work . . . . .	152
3 Modelling the homogeneous Available-To-Promise for fruit supply chains . . .	153
4 Modelling the shelf-life. . . . .	154
5 Shelf life-based pricing policy . . . . .	156
6 Numerical example . . . . .	157
7 Conclusion. . . . .	159
8 Publication data . . . . .	160
Bibliography . . . . .	160

Chapter VI: Mathematical modelling of the order-promising process for fruit supply chains considering the perishability and sub-types of products 165

1 Introduction. . . . .	166
2 Related work and contributions . . . . .	168
2.1 OPP-related models . . . . .	168
2.2 Operations research models in agri-food supply chains . . . . .	169
2.3 Contributions of our work. . . . .	171
3 Problem description . . . . .	172
3.1 The physical FSC configuration . . . . .	172
3.2 Final products. . . . .	173
3.3 Customer order proposals . . . . .	175
3.4 Order promising process (OPP) . . . . .	176
4 FSC-OPP model description . . . . .	177
4.1 Notation . . . . .	177

4.2 FSC-OPP model formulation . . . . .	181
4.2.1 Objective Function . . . . .	181
4.2.2 Constraints . . . . .	182
4.3 Implementing the FSC-OPP model into a dynamic batching mode. . . . .	187
5 Experimental design: application to an orange and tangerine supply chain . .	188
5.1 Input data overview . . . . .	188
5.2 Experimental design . . . . .	189
5.3 Experimental results . . . . .	189
5.3.1 Interaction between the objectives . . . . .	190
5.3.2 Impact of price variation on the objectives . . . . .	192
5.3.3 Impact of SL on the objectives . . . . .	192
5.3.4 Computational efficiency . . . . .	192
5.3.5 Managerial insights . . . . .	193
6 Conclusions and future research lines . . . . .	196
7 Publication data . . . . .	197
Bibliography . . . . .	197
Appendices . . . . .	204
A Acronyms . . . . .	204
B Description of the input data for the OPP Model . . . . .	205

## Chapter VII: Compositions of possibilistic variables and state functions:

application to an order promising model for perishables	214
1 Introduction . . . . .	215
2 Modelling compositions with possibilistic variables . . . . .	218
2.1 Basic concepts . . . . .	218
2.2 Compositions . . . . .	221
2.3 Using compositions in practice . . . . .	225
3 Modelling State functions . . . . .	225
3.1 State functions . . . . .	225
4 Application to the order promising process for perishables . . . . .	227
4.1 Notations . . . . .	229
4.2 Mathematical modelling . . . . .	230
4.3 Equivalent MILP model . . . . .	232
4.3.1 Computations on the price for the objective function . . . . .	233

4.3.2 Computations on the possibilistic constraints . . . . .	234
4.3.3 Equivalent MILP model . . . . .	235
4.3.4 Implementing dynamic batching mode . . . . .	236
5 Experimental design: application to an orange an tangerine supply chain . . .	237
5.1 Input data overview . . . . .	237
5.2 Definition of evaluation instances . . . . .	237
5.3 Results . . . . .	238
5.3.1 Committed orders and generated profits . . . . .	238
5.3.2 Managerial insights . . . . .	240
5.3.3 Computational efficiency . . . . .	242
6 Conclusions . . . . .	242
Bibliography . . . . .	243
Appendices . . . . .	247
A Input data . . . . .	247
Chapter VIII: Conclusions and future research lines . . . . .	255
1 Contributions of the dissertation: general overview . . . . .	255
1.1 Inherent LHP characteristics addressed . . . . .	256
1.2 Mathematical modelling contributions . . . . .	258
1.3 Final remarks on LHP inherent uncertainty . . . . .	261
2 Future research lines . . . . .	262
2.1 Inherent LHP characteristics . . . . .	263
2.2 Other OPP characteristics . . . . .	263
2.3 Mathematical modelling and resolutions tools . . . . .	264
Appendix A: Mathematical modelling of uncertainty in non-homogeneous lots. . . . .	266
1 Introduction. . . . .	267
2 Background literature . . . . .	267
3 Modelling Context . . . . .	268
4 LHP modelling in production lots . . . . .	269
4.1 Deterministic LHP modelling in production lots . . . . .	270
4.2 Modelling the LHP uncertainty in production lots . . . . .	270
5 Conclusions . . . . .	273
6 Publication data . . . . .	273

Bibliography . . . . .	273
Appendix B: Journal authorizations	276