

Edited by Efstratios N. Pistikopoulos,
Michael C. Georgiadis, and Vivek Dua

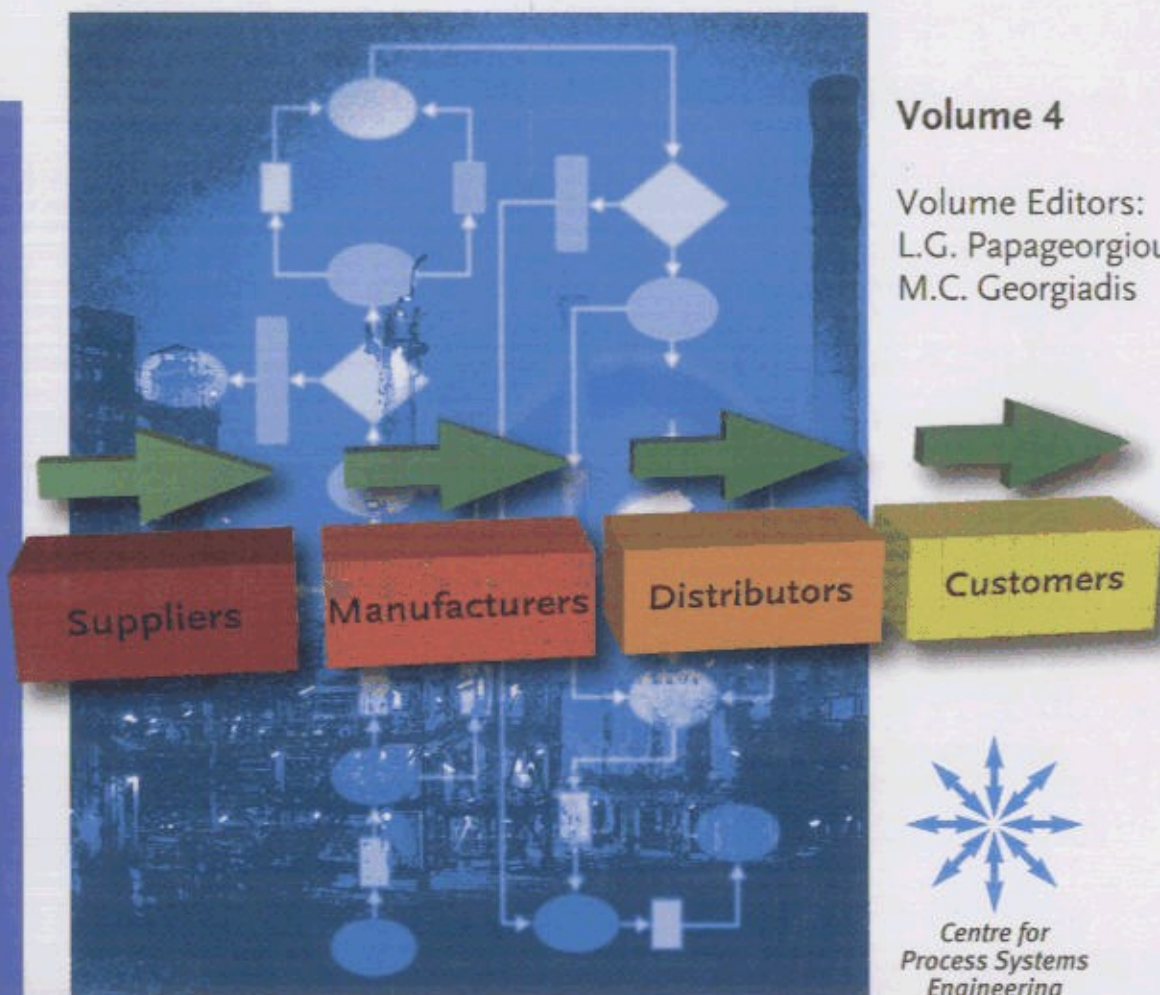
 WILEY-VCH

Supply Chain Optimization

Part II

Volume 4

Volume Editors:
L.G. Papageorgiou,
M.C. Georgiadis




Centre for
Process Systems
Engineering

Contents

Preface – Volume 4: Supply Chain Optimization	<i>XIII</i>
List of Authors	<i>XVII</i>

1	Supply Chains of High-Value Low-Volume Products	1
	<i>R. Sousa, N. Shah, L. G. Papageorgiou</i>	<i>1</i>
1.1	Introduction	1
1.1.1	Pharmaceutical Industry	3
1.2	Literature on Supply-Chain Modeling and Optimization	4
1.2.1	Case Studies	4
1.2.2	Deterministic Studies	6
1.2.3	Case Study Part I: Problem Statement	9
1.3	Stochastic Models	11
1.3.1	Stochastic Programming with Recourse	12
1.3.2	Stochastic Dynamic Programming (for Optimal Control)	13
1.3.3	Works in Planning Optimization Under Uncertainty	13
1.3.3.1	Stochastic Programming, Probability-Based Approach	13
1.3.3.2	Stochastic Programming, Scenario-Based Approach	14
1.3.3.3	Stochastic Dynamic Programming Approach	16
1.3.4	Case Study Part II: Planning Under Uncertainty	16
1.3.4.1	Scenarios	17
1.4	Solution Algorithms	18
1.4.1	Decomposition and Hierarchical Algorithms	18
1.4.2	Hybrid Methods	20
1.4.2.1	Lagrangian Decomposition	20
1.4.2.2	Genetic Algorithms	21
1.4.3	Case Study Part III: Solution Methodology	22
1.4.3.1	Solution Algorithm Performance	22
1.4.3.2	Financial Risk	24
1.4.3.3	Comments	24
1.5	Summary	25

2	Solving Multiple Vehicle Pickup and Delivery Problems in Multisite Systems by a Rigorous Optimization Approach	29
	<i>R. Dondo, C. A. Méndez, J. Cerdá</i>	29
2.1	Introduction	30
2.1.1	Previous Heuristic Approaches	31
2.1.2	Exact Optimization Methods	32
2.2	The Problem Definition	34
2.3	The Problem Mathematical Formulation	35
2.3.1	The Problem Constraints	36
2.3.1.1	Assignment Constraints	36
2.3.1.2	Routing-Cost Defining Constraints	37
2.3.1.3	Arrival-Time Defining Constraints	39
2.3.1.4	Vehicle-Load Defining Constraints	40
2.3.2	The Problem Objective Function	43
2.4	Time Window-Based Variable and Constraint Elimination Rules	43
2.4.1	Preassigning Vehicles to Transportation Requests	45
2.5	Numerical Results and Discussion	46
2.6	Conclusions	56
3	A Real Time Approximate Dynamic Programming Approach: A High Dimensional Supply Chain Application	61
	<i>N. E. Pratikakis, M. J. Realff, H. Lee</i>	61
3.1	Introduction	61
3.1.1	Chapter Structure	63
3.2	Dynamic Programming	63
3.2.1	The Value Function	63
3.2.2	Markov Decision Processes	64
3.2.3	From Value Iteration to Asynchronous Value Iteration to Real-Time Dynamic Programming	65
3.2.4	A Review Of Approximate Dynamic Programming Techniques	66
3.2.4.1	Minimizing the COD Concerning $ S $	66
3.2.4.2	Minimizing the COD Concerning $ A $	67
3.2.4.3	Minimizing the COD Concerning the Expectation Operator	68
3.2.4.4	Value Function Approximators	68
3.3	A High-Dimensional Supply Chain Case Study	69
3.3.1	Introduction	69
3.3.2	Mathematical Modelling of the Supply Chain	70
3.3.3	Sets	70
3.3.4	Material Balances at Each Tank	70
3.3.4.1	Constraints on $y_{T,C,(P_m)}(t)$	71
3.3.5	Reaction and Separation Processes – The Determination of $Pr_{u,p}(t)$	73
3.3.5.1	Reaction Processes	73
3.3.5.2	Separation Processes	74

3.3.5.3	Hard Constraints	74
3.3.6	Decision Variables	75
3.3.7	Objective Function	75
3.3.7.1	Net Profit $p(t)$	75
3.3.7.2	Net Cost $c(t)$	75
3.4	Formulating the Problem as an MDP	76
3.4.1	State Variables	76
3.4.2	Decision Variables	76
3.4.3	Transition Function	76
3.4.4	Objective Function	77
3.4.5	Concluding Remarks	77
3.5	A Real-Time Approximate Dynamic Programming Algorithm	78
3.5.1	The Greedy RTADP Algorithm	79
3.5.2	Key Elements of A_{sub}	80
3.5.3	On Calculating $J_t^\pi(s_t)$	81
3.6	Simulation Results	82
3.6.1	Simulation Procedure	83
3.6.2	Performance Comparison	84
3.7	Conclusions	86
:		
4	Robust Supply-Chain Operations through Rescheduling	89
	<i>A. Adhitya, R. Srinivasan, I. A. Karimi</i>	89
4.1	Introduction	89
4.2	Refinery Supply Chain	91
4.3	Rescheduling Problem Statement	92
4.3.1	Literature Review	95
4.4	Rescheduling Methodologies	96
4.4.1	Heuristic-Based Rescheduling	96
4.4.2	Model-Based Rescheduling	98
4.5	Case Study	105
4.6	Discussions	117
:		
5	Supply Chain Tactical Optimization in the Fruit Industry	121
	<i>G. L. Masini, A. M. Blanco, N. Petracci, J. A. Bandoni</i>	121
5.1	Introduction	122
5.2	Literature Review	124
5.3	Fruit Industry Supply Chain Description	126
5.3.1	Farms	126
5.3.2	Packaging Plants	126
5.3.3	Cold Storage	127
5.3.4	Fruit Reception Sites	127
5.3.5	Milling Plants	127
5.3.6	Concentrated Juice Plants	127

5.3.7	Cider Plants	128
5.3.8	Clients	128
5.3.9	Third Party Suppliers and Customers	128
5.3.10	Transportation	128
5.3.11	Global FISC Operations	128
5.3.12	Tactical Model Scope	129
5.4	Mathematical Programming Model	130
5.4.1	Fruit Production in Farms	130
5.4.2	Allocation of Fresh Fruit from Own Farms	131
5.4.3	Fruit Reception at PPs	132
5.4.4	Fruit Processing at PPs	132
5.4.5	Waste Fruit from PPs	132
5.4.6	Packed Fruit from PPs and TPSs	133
5.4.7	Fruit Balance at CSFs	133
5.4.8	Fruit Balance at FRSSs	134
5.4.9	Fruit Balance at MPs	135
5.4.10	Raw Material Reception at CJPs	135
5.4.11	Fruit Processing at CJPs	136
5.4.12	Juice Storage at CJSs	136
5.4.13	Raw Material Reception at CPs	136
5.4.14	Fruit Processing at CPs	137
5.4.15	Packed Fruit Delivery to Clients	137
5.4.16	Concentrated Juice Delivery to Clients	137
5.4.17	Third Party Material Availability	137
5.4.18	Product Delivery Constraints	138
5.4.19	Raw Material Costs	139
5.4.20	Final Products Purchase Cost	140
5.4.21	Transportation Costs	140
5.4.22	Cold Storage Cost (Third Party Rental)	143
5.4.23	Operating Costs	143
5.4.24	Sales Income	144
5.4.25	Cold Storage Capacity Rental Income	145
5.4.26	Objective Function	145
5.4.27	Company Supply Chain Optimization Problem	145
5.5	Results and Discussion	145
5.6	Conclusions and Future Work	154
6	Short-Term Scheduling of Batch and Continuous Processes	173
	<i>M. A. Shaik, Ch. A. Floudas</i>	173
6.1	Classification of Scheduling Formulations	173
6.1.1	Time Representation	173
6.1.2	Characteristics of Process Scheduling Problems	175
6.1.2.1	Processing Sequences	175
6.1.2.2	Processing Modes of Operation	176

6.1.2.3	Intermediate Storage Policies	176
6.1.2.4	Demand Patterns	177
6.1.2.5	Resource Considerations	177
6.1.2.6	Changeovers	177
6.1.2.7	Performance Criteria	177
6.2	Short-Term Scheduling of Batch Processes	177
6.2.1	Unit-Specific Event-Based Model of Ierapetritou and Floudas [29] (I&F)	178
6.2.2	Global Event-Based Model of Castro and coworkers [21, 22]	179
6.2.3	Global Event-Based Model of Maravelias and Grossmann [28] (M&G)	181
6.2.4	Slot-Based Model of Sundaramoorthy and Karimi [10] (S&K)	183
6.2.5	Computational Studies	185
6.2.5.1	Example 1	185
6.2.5.2	Example 2	188
6.2.5.3	Example 3	189
6.3	Short-Term Scheduling of Continuous Processes	195
6.3.1	Unlimited Intermediate Storage	197
6.3.1.1	Allocation Constraints	197
6.3.1.2	Capacity Constraints for Processing Tasks	197
6.3.1.3	Material Balances	197
6.3.1.4	Demand Constraints	198
6.3.1.5	Duration Constraints for Processing Tasks	199
6.3.1.6	Sequencing Constraints	199
6.3.1.7	Extra Tightening Constraint	201
6.3.2	Dedicated Finite Intermediate Storage with Storage Bypassing Allowed	201
6.3.2.1	Storage Bypassing Allowed	201
6.3.3	No Intermediate Storage	202
6.3.4	Flexible Finite Intermediate Storage with Storage Bypassing Allowed	202
6.3.4.1	Allocation Constraints for Storage Tasks	203
6.3.4.2	Capacity Constraints for Storage Tasks	203
6.3.4.3	Material Balances	203
6.3.4.4	Duration Constraints for Storage Tasks	204
6.3.4.5	Sequencing Constraints. Different Tasks in Different Units for Storage Tasks	204
6.3.5	Dedicated and Flexible Finite Intermediate Storage without Storage Bypassing	205
6.3.5.1	Dedicated-Finite-Intermediate-Storage Case without Bypassing of Storage	205
6.3.5.2	Flexible-Finite-Intermediate-Storage Case without Bypassing of Storage	206
6.3.6	Computational Study	207
6.3.6.1	Example 4	207

6.3.6.2	Unlimited Intermediate Storage (Case A)	210
6.3.6.3	No Intermediate Storage (Case B)	210
6.3.6.4	Flexible Finite Intermediate Storage (Case C)	211
6.4	Conclusions	214
7	Modeling and Optimization of Refinery Operations Considering Uncertainty	219
	<i>Z. Jia, M. G. Ierapetritou</i>	219
7.1	Introduction	219
7.2	Refinery Scheduling	221
7.3	Uncertainty Analysis	222
7.3.1	Multiobjective Robust Optimization	222
7.3.2	Parametric Mixed Integer Linear Programming (pMILP)	224
7.4	Case Studies	225
7.5	Summary and Future Work	234
8	Production and Inventory Planning for Stock Preparation in the Tissue Paper Industry	237
	<i>J. Westerlund, M. Hästbacka, J. Kaplin, T. Westerlund</i>	237
8.1	Introduction	237
8.2	Mathematical Programming as a Tool for Production Optimization	239
8.3	Metsä Tissue Mänttä Mill	240
8.3.1	Process Description	241
8.3.2	Corporate Supply Planning at Metsä Tissue Corporation	244
8.4	The MISPT Tool	245
8.4.1	The MISPT Architecture	246
8.4.2	The MISPT Graphical-User Interface	248
8.4.3	The MISPT Tool for Daily Production Planning	249
8.4.3.1	Planning of Production Stops	250
8.4.3.2	Aging Profiles	250
8.4.3.3	Time Synchronization	250
8.4.4	The MISPT Tool for Strategic Planning	251
8.5	The Mixed-Time MILP Model	252
8.5.1	Mathematical Formulation	253
8.6	Illustrative Case Examples	255
8.6.1	Case Example 1	256
8.6.1.1	Sequence-Dependent Changeovers	257
8.6.1.2	MISPT Results for Case Example 1	259
8.6.2	Case Example 2	263
8.6.3	Case Example 3	265
8.7	Discussion	266

9	Production Planning in Process Systems Engineering	269
	<i>C. Sung, C. T. Maravelias</i>	269
9.1	Introduction	269
9.2	Background	271
9.2.1	Problem Statement	271
9.2.2	Classical Mathematical Programming Formulations	271
9.2.3	Software Systems	273
9.2.4	Challenges in Production Planning in the Chemical Industry	274
9.3	Integration of Production Planning and Scheduling	275
9.3.1	Scheduling Subproblems	275
9.3.1.1	Integration with Detailed Scheduling Formulations	275
9.3.1.2	Integration with <i>Approximate</i> Scheduling Models	275
9.3.1.3	Integration with Surrogate Models Obtained Offline	276
9.3.2	Solution Methods	276
9.3.2.1	Full-Space Methods	277
9.3.2.2	Hierarchical Methods	277
9.3.2.3	Iterative Methods	278
9.4	Applications and Extensions	278
9.5	Conclusions	279
10	The Supply Chain as a Dynamical System	285
	<i>K. R. Jillson, E. J. Dozal-Mejorada, B. E. Ydstie</i>	285
10.1	Introduction	285
10.2	Literature Review	287
10.2.1	How did the Field Start?	287
10.2.2	What Needs and Areas are Being Addressed?	288
10.2.2.1	Environmental	288
10.2.2.2	Pharmaceutical	288
10.2.2.3	Semiconductors	289
10.2.2.4	Energy	289
10.2.3	What Modeling Approaches and Solutions Exist?	289
10.2.4	Back to Dynamics	290
10.3	Problem Formulation	292
10.3.1	The Beer Game	298
10.4	Inventory Control	303
10.5	Assembly, Disassembly, and Packaging	309
10.5.1	Bounds on Storage Requirements	314
10.5.2	Feedback Scheduling	319
10.6	Flow Control and Load Balancing	323
10.7	Summary and Conclusions	334
	Index	339