

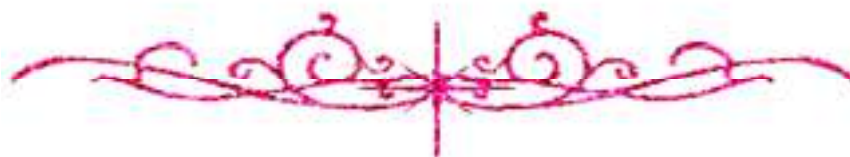
Safaa Mahmoud



بسم الله الرحمن الرحيم

مركز الشبكات وتكنولوجيا المعلومات

قسم التوثيق الإلكتروني



Safaa Mahmoud



جامعة عين شمس

التوثيق الإلكتروني والميكرو فيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغييرات





Ain Shams University
Faculty of Engineering
Mechanical Design and Production Department

Joint Lot-sizing and Scheduling Optimization in Multi-echelon Supply Chains

A Thesis submitted in partial fulfillment of the requirements of the degree
of Master of Science in Mechanical Engineering
(Design and Production Engineering)

By

Ahmed Othman Shawky El-Meehy
Bachelor of Science in Mechanical Engineering
(Design and Production Engineering)

Faculty of Engineering, Ain Shams University, 2013

Supervised by

Prof. Amin M. K. El-Kharbotly

Dr. Mohammed M. El-Beheiry

Cairo - (2019)



Ain Shams University-Faculty of Engineering
Mechanical Design and Production Engineering Department
**Joint Lot-sizing and Scheduling Optimization
in Multi-echelon Supply Chains**

By

Ahmed Othman Shawky El-Meehy

B.Sc. in Mechanical Engineering (Design and Production Engineering)

Faculty of Engineering – Ain Shams University

EXAMINERS COMMITTEE

Prof. Mohamed Ibrahim El-Sayed Etman

Faculty of Engineering-Helwan University.

Prof. Nahid H. Afia

Design and Production Engineering Dept.

Faculty of Engineering, Ain Shams University

Prof. Amin Mohamed Kamel El-Kharbotly

Design and Production Engineering Dept.

Faculty of Engineering, Ain Shams University

(Supervisor)

Date: / /2019

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Mechanical Engineering (Design and Production Engineering), Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Student Name

Ahmed Othman Shawky El-Meehy

Signature

.....

Researcher Data

Name	: Ahmed Othman Shawky El-Meehy
Date of birth	: 23/11/1990
Place of birth	: Kingdom of Saudi Arabia
Last academic degree	: B.Sc.
Field of specialization	: Design and Production Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: September 2013
Current job	: Demonstrator at the Faculty of Engineering, Ain Shams University

Abstract

This Thesis addresses the Problem of Joint Lot-Sizing and Scheduling (JLSS) for a multi-echelon SC in which multiple materials are purchased from suppliers to produce multiple products. The SC is composed of two suppliers, single manufacturing facility and a distribution center. The products use the same materials with different ratios. JLSS decision is optimized using mixed integer non-linear programming model such that the demands of different products are satisfied as possible while the SC total profits are maximized. SC total profits are the difference between total SC revenues and total SC costs. SC costs include material purchasing, processing, inventory holding for both items and finished products, changeover and shortage penalty for every undelivered product. The planning horizon is composed of several periods, for each the JLSS decision variables are optimized maximizing SC profits. The effects of inventory holding, shortage penalty and changeover costs are studied for two approaches of the production schedules, namely, unconstrained and constrained levelled production approaches to production schedules. For the unconstrained production schedule, production quantities of products are allowed to differ from period to period, while the constrained production obligates the production schedule to produce equal quantity from each product each period. The effects of production capacity at the manufacturing facility and finished products inventory capacity at the DC on SC performance are also studied. Results show that flexibility in the production schedule (unconstrained levelled production approach) results in higher SC performance especially when the production capacity is limited.

Keywords: Joint Lot-Sizing and Scheduling, Supply Chain optimization, Integrated Supply Chain

Table of Contents

Statement.....	iv
Researcher Data	vi
Abstract	viii
Table of Contents	ix
List of Tables.....	xvi
List of Figures	xvii
Nomenclature.....	xxi
Abbreviations.....	xxiv
1 Chapter 1: Introduction.....	1
1.1. Supply chain management decisions	1
1.2. Integrating supply chain decisions	2
1.3. Integrating lot-sizing and scheduling decisions	3
1.4. The Joint Lot-Sizing and Scheduling problem (JLSS)	4
2 Chapter 2: Literature Review.....	6
2.1 Introduction.....	6
2.2 The Supply Chain Joint Economic Lot-sizing Problem (JELP).....	6
2.2.1 Basic single-vendor single buyer JELP	7
2.2.2 JELP with multiple actors in one of the two echelons	12
2.2.3 JELP with multi-echelons supply chain.....	13
2.3 Supply chain Lot-Sizing and Scheduling (LSS).....	18
2.3.1 Lot-sizing and Scheduling	18
2.3.1.1 Models based on single period approach	19
2.3.1.2 Models based on cyclic approach.....	19
2.3.2 Joint Lot-Sizing and Scheduling (JLSS).....	21
2.3.2.1 Models based on single period approach	21

2.3.2.2	Models based on cyclic approach.....	22
2.3.2.3	Models based on multiple-period approach.....	25
2.4	Findings of literature review.....	29
2.5	Thesis objectives	30
3	Chapter 3: The proposed Joint Lot-Sizing and Scheduling Model	31
3.1	Introduction.....	31
3.2	Problem Description and Assumptions	31
3.3	Mathematical Model.....	33
3.3.1	The Objective Function:	33
3.3.1.1	Total Supply Chain Revenues.....	34
3.3.1.2	Cost elements.....	35
3.3.1.2.1	Total Supply Chain Material Purchasing costs.....	35
3.3.1.2.2	Total Supply Chain Processing costs	35
3.3.1.2.3	Total Supply Chain Final Products inventory holding costs	35
3.3.1.2.4	Total Supply Chain Raw Material Inventory holding costs	36
3.3.1.2.5	Total Supply Chain Shortage penalty costs.....	36
3.3.1.2.6	Total Supply Chain Changeover cost.....	36
3.3.2	Model Constraints:	37
3.3.2.1	Capacity Constraints:.....	37
3.3.2.1.1	Production capacities of suppliers:	37
3.3.2.1.2	Production capacity at facility	37
3.3.2.1.3	Inventory Holding capacity at facility	38
3.3.2.2	Relation between purchased raw materials and production requirement:.....	38
3.3.2.3	Relation between demand and delivered quantity:.....	38
3.3.2.4	Material balance constraint for finished products:.....	39
3.3.2.5	Material balance constraint for raw materials:	39

3.3.2.6	Constraint on raw materials that cannot be purchased from certain suppliers:	39
3.3.2.7	Constraints for controlling production integer and binary variables:	40
3.3.2.8	Additional constraint to obligate levelled production:	40
3.3.2.9	Non-negativity constraints:	41
4	Chapter 4: Design of Experiments	42
4.1	Objectives of the research	42
4.2	Numerical Experimentations:	42
4.2.1	Multi-item Multi-product Joint Lot-Sizing and Scheduling Problem	43
4.2.2	Studying the effect of cost parameters on supply chain performance (unconstrained levelled production):	44
4.2.2.1	Investigating the effect of Changeover costs	45
4.2.2.2	Investigating the effect of Inventory holding and shortage costs	45
4.2.3	Studying the effect of constrained Levelled Production decision parameters	45
4.2.4	Studying the effect of production and inventory capacities	46
5	Chapter 5: Results and Discussion	47
5.1	Introduction	47
5.2	Validating the Multi-items Multi-products JLSS model	47
5.2.1	The Two-items Two-products case	48
5.2.2	The Two-items Three-products case	49
5.2.3	The Three-items Three-products case	49
5.3	Unconstrained levelled production Lot-sizing and Scheduling	50
5.3.1	Effect of Changeover Cost ' Co '	50
5.3.2	Effects of Inventory ' Chp_n ' and Shortage Penalty ' Cs ' Costs	57
5.4	Constrained levelled production Lot-sizing and Scheduling	72
5.4.1	Effect of Changeover cost ' Co '	72
5.4.2	Effects of Inventory ' Chp_n ' and Shortage Penalty ' Cs ' Costs	75

5.5	Comparing results of constrained and unconstrained levelled production approaches.....	84
5.5.1	Effect of changeover costs ' Co '	85
5.5.2	Effect of inventory holding ' Chp_n ' cost at different shortage penalty costs	89
5.5.2.1	SC Profits	89
5.5.2.2	Fill Rate	91
5.5.2.3	Service Levels for unconstrained levelled production approach	92
5.5.2.4	Number of changeovers	95
5.5.2.5	Standard deviations of quantities	96
5.5.2.6	Effect of (Chp/Cs) ratio on Service Levels of the two products	98
5.6	Effect of Production and Inventory Capacities.....	100
5.6.1	Effect of Production Capacity ' w ' on JLSS Decisions for the unconstrained levelled production approach.....	100
5.6.1.1	Insufficient Production Capacity ' $w=150$ '	100
5.6.1.2	Marginal Production Capacity ' $w=250$ '	102
5.6.1.3	Surplus Production Capacity ' $w=350$ '	102
5.6.2	Effect of Production Capacity ' w ' at different Inventory capacities on SC Performance	106
6	Chapter 6: Conclusions and Future Work	112
6.1	Conclusions.....	112
6.1.1	Joint Lot-Sizing and Scheduling (JLSS) for the unconstrained levelled production approach.....	112
6.1.2	Joint Lot-Sizing and Scheduling (JLSS) for the constrained levelled production approach.....	113
6.1.3	Comparing Constrained and unconstrained levelled production approaches	113
6.1.4	Effects of Production and Inventory capacities	114
6.2	Future Work.....	114
	Bibliography	116
	Appendices	121

A. Appendix A	1
Results of the study of the effect of shortage penalty cost 'Cs' on SC performance measures for constrained and unconstrained approaches	1
SC profits.....	1
Fill Rate.....	2
Service levels for the unconstrained levelled production approach	4
Service levels for the constrained levelled production approach.....	5
Number of changeovers	6
Standard deviations of quantities.....	7
B. Appendix B.....	1
Results of the study of the effect of Inventory Capacity 'k' on SC performance for unconstrained approach and different production capacities.....	1
Performance Measures	1
Service Levels.....	2
Standard deviations of quantities.....	4