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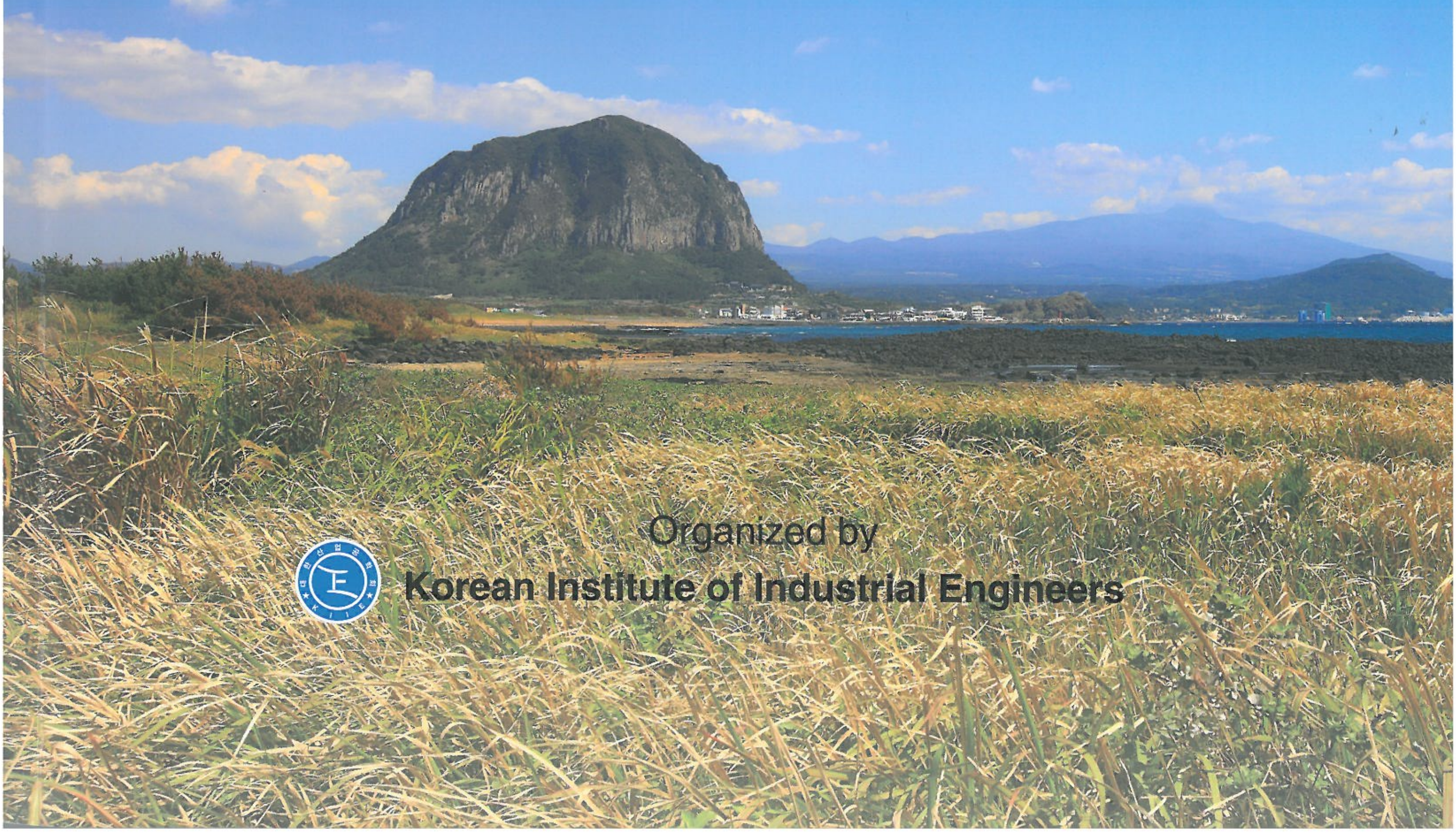
APIEMS

APIEMS 2014

Abstracts

The 15th
Asia Pacific Industrial Engineering
and **Management Systems Conference**

> October 12~15, 2014
> Ramada Plaza Jeju Hotel, Jeju, Korea



Organized by
Korean Institute of Industrial Engineers

Message from the APIEMS President

Greeting and a warm welcome to the participants of the 15th Asia Pacific Industrial Engineering and Management Systems Conference. Started in 1998, APIEMS has grown to become the premier conference for industrial engineering and management systems in the region with participants from all around the world. The main theme of this year conference: "Sustainable Industrial Systems and Big Data Management", is an attempt to address the balance among economic and technical development, social development, and environmental protection in this fast changing world.

I congratulate and thank Prof. Dr. Chi-Hyuck Jun, the conference chair, whose leadership made this APIEMS 2014 conference possible. We are also grateful for the enthusiastic support of APIEMS from the KIIE and the Korea research community.

On behave of the Asia Pacific Industrial Engineering and Management Society, I wish you a successful conference with many thoughtful discussions and debates with old and new friends.

Professor Voratas Kachitvichyanukul

APIEMS President, (2013-2014)

Professor of Industrial & Manufacturing Engineering

Dean, School of Engineering and Technology

Asian Institute of Technology, THAILAND

Message from the General Chair

Welcome to APIEMS 2014 in Jeju City, a beautiful island located at the most south of Korea. It is our great pleasure to organize this conference, which is supported by Korean Institute of Industrial Engineers (KIIE). APIEMS conferences have rapidly emerged as an important forum for exchange of ideas and information about latest developments in the field of industrial engineering and management systems among professionals mostly from Asia-Pacific countries. APIEMS 2014 conference encourages contributors to address the topical theme: Sustainable Industrial Systems and Big Data Management. Papers will represent the latest academic thinking and successful case examples. The wider audience will benefit from the knowledge and experience of leading practitioners and academics in this area.

The conference seeks research contributions from researchers, educators, modelers, software developers, users and practitioners. We hope that you enjoy participating in APIEMS 2014 and staying in Jeju.

Professor Chi-Hyuck Jun

General Chair, APIEMS 2014

Industrial & Management Engineering

POSTECH, Korea

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Keynote Speech

Keynote Speech I
Research Issues in Future Logistics

Oct 13 (Monday) 11:00-12:00

Room: Ramada-1

Chung– Yee Lee
Hong Kong University of Science and Technology, China

Dr. Chung-Yee Lee is Chair Professor/Cheong Ying Chan Professor of Engineering in the Department of Industrial Engineering & Logistics Management at Hong Kong University of Science and Technology. He served as Department Head for seven years (2001- 2008). He is also the Founding and Current Director of Logistics and Supply Chain Management Institute. He is a Fellow of the Institute of Industrial Engineers in U.S. and also a Fellow of Hong Kong Academy of Engineering Science. Before joining HKUST in 2001, he was Rockwell Chair Professor in the Department of Industrial Engineering at Texas A&M University. He worked as a plant manager and also had few years consulting experience in Taiwan. In the past thirty years he has engaged in more than forty research projects sponsored by NSF, RGC, ITF, IBM, Motorola, AT&T Paradyne, Harris Semicon ductor, Northern Telecom, Martin Marietta, Hong Kong Air Cargo Terminal, Hongkong International Terminal, Philips Medical, ...,etc.

His search areas are in logistics and supply chain management, scheduling and inventory management. He has published more than 130 papers in refereed journals. According to an article in Int. J. Prod. Eco. (2009), which looked at all papers published in the 20 core journals during last 50 years in the field of production and operations management, he was ranked No. 6 among all researchers worldwide in h-index.

He received a BS degree in Electronic Engineering (1972) and a MS degree in Management Sciences (1976) both from National Chiao-Tung University in Taiwan. He also received a MS degree in Industrial Engineering from Northwestern University (1980) and PhD degree in Operations Research from Yale University (1984).

Keynote Speech II
Data-Driven Decision Making in Manufacturing: Lessons Learned and Future Opportunities

Oct 14 (Tuesday) 11:00-12:00

Room: Ramada-1

Ronald G. Askin
Arizona State University, USA

Ronald G. Askin, Ph.D., is a Professor of Industrial Engineering and Director of the School of Computing, Informatics, and Decision Systems Engineering at Arizona State University. Professor Askin received his B. S. in Industrial Engineering from Lehigh University followed by an M.S. in Operations Research and PhD in Industrial and Systems Engineering from the Georgia Institute of Technology. He has over 30 years of experience in the development, teaching and application of methods for systems design and analysis with particular emphasis on production and material flow systems. Other interests include quality engineering and decision analysis. He has published over 120 journal and conference proceedings papers in these areas.

Dr. Askin is a Fellow of the Institute of Industrial Engineers (IIE) and serves as Editor-in-Chief of IIE Transactions. He has served on the IIE Board of Trustees, as President of the IIE Council of Fellows, Chair of the Association of Chairs of Operations Research Departments (ACORD) Chair of the Industrial Engineering Academic Department Heads (CIEADH) and President of the INFORMS Manufacturing and Service Operations Management Society (MSOM). He was also General Chair of the 2012 INFORMS Annual Conference. His list of awards includes a National Science Foundation Presidential Young Investigator Award, the Shingo Prize for Excellence in Manufacturing Research, IIE Joint Publishers Book of the Year Award (twice), IIE Transactions on Design and Manufacturing Best Paper Award (twice), the Eugene L. Grant best paper award from The Engineering Economist, and the IIE Transactions Development and Applications Award.

Keynote Speech III
Big Data Management

Oct 14 (Tuesday) 13:00-14:00

Room: Ramada-1

Sungzoon Cho
Seoul National University, Korea.

Sungzoon Cho is currently professor of Industrial Engineering Department, the director of Data Mining Center at Seoul National University (SNU) and a member of Government 3.0 Committee of Korean government. He is on the editorial board of International Journal of Operations Research and Information Systems and International Journal of Cognitive Biometrics. He served as the presi yundai Motors, Hyundai Heavy Industries, POSCO, Daewoo Shipbuilding and Marine Engineering, LG Electronics, Doosan Infracore, SK Hynix, SK Telecommunication and CJ. He advised nine PhDs and 56 Master students. He teaches Data Mining and Computational Intelligence at SNU as well as at firms. He received BS and MS in Industrial Engineering at SNU. He won a Fulbright Scholarship to obtain Masters and PhD at University of Washington in Seattle, US, and University of Maryland in College Park, US, respectively.

Conference at a Glance

Oct 12 (Sunday)

10:00-18:00	Registration
13:00-17:20	Excursion
	Registration
18:00-20:00	Welcome Reception

Oct 13 (Monday)

08:00-17:00	Registration
08:30-10:10	Technical sessions MA
10:10-10:30	Coffee break
10:30-11:00	Opening addresses : APIEMS President, KIIE President, General Chair
11:00-12:00	Keynote speech I (Prof. Chung-Yee Lee: Research issues in Future Logistics)
12:00-13:30	Lunch
13:30-15:30	Technical sessions MB
15:30-15:50	Coffee break
15:50-17:50	Technical sessions MC

Oct 14 (Tuesday)

08:00-17:00	Registration
08:40-10:40	Technical sessions TA
10:40-11:00	Coffee break
11:00:12:00	Keynote speech II (Prof. Ronald Askin: Data-Driven Decision Making in Manufacturing)
12:00-13:00	Lunch
13:00-14:00	Keynote speech III (Prof. Sungzoon Cho: Big Data Management)
14:00-14:20	Coffee break
14:20-16:00	Technical sessions TB
16:00-16:20	Coffee break
16:20-18:00	Technical sessions TC
13:00-18:00	Poster Session
18:30-21:00	General Reception

Oct 15 (Wednesday)

08:00-12:00	Registration
08:30-10:10	Technical sessions WA
10:10-10:30	Coffee break
10:30-12:10	Technical sessions WB
12:10-13:30	Lunch

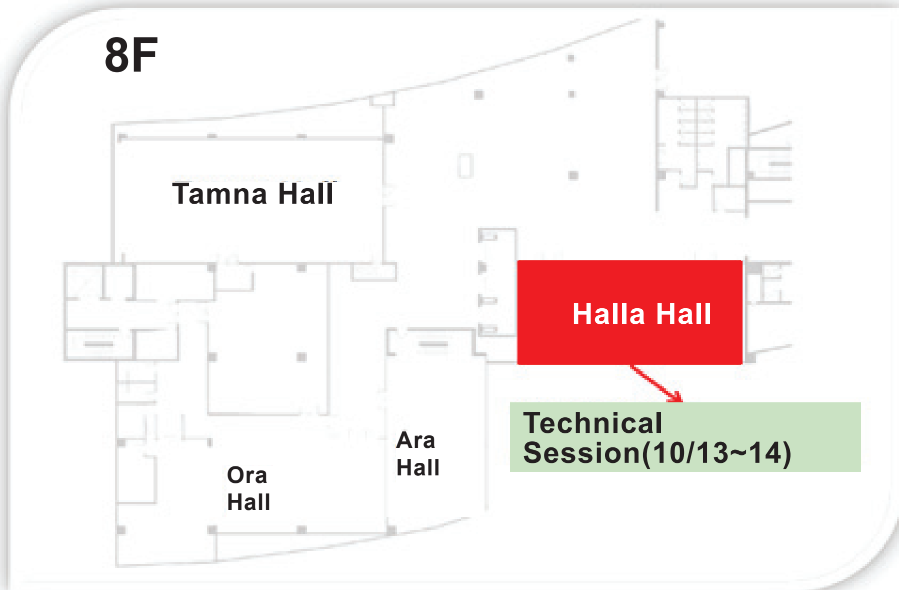
Oct 12 (Sunday)	
10:00-18:00	**Registration**
13:00-17:20	**Excursion**
18:00-20:00	**Welcome Reception**

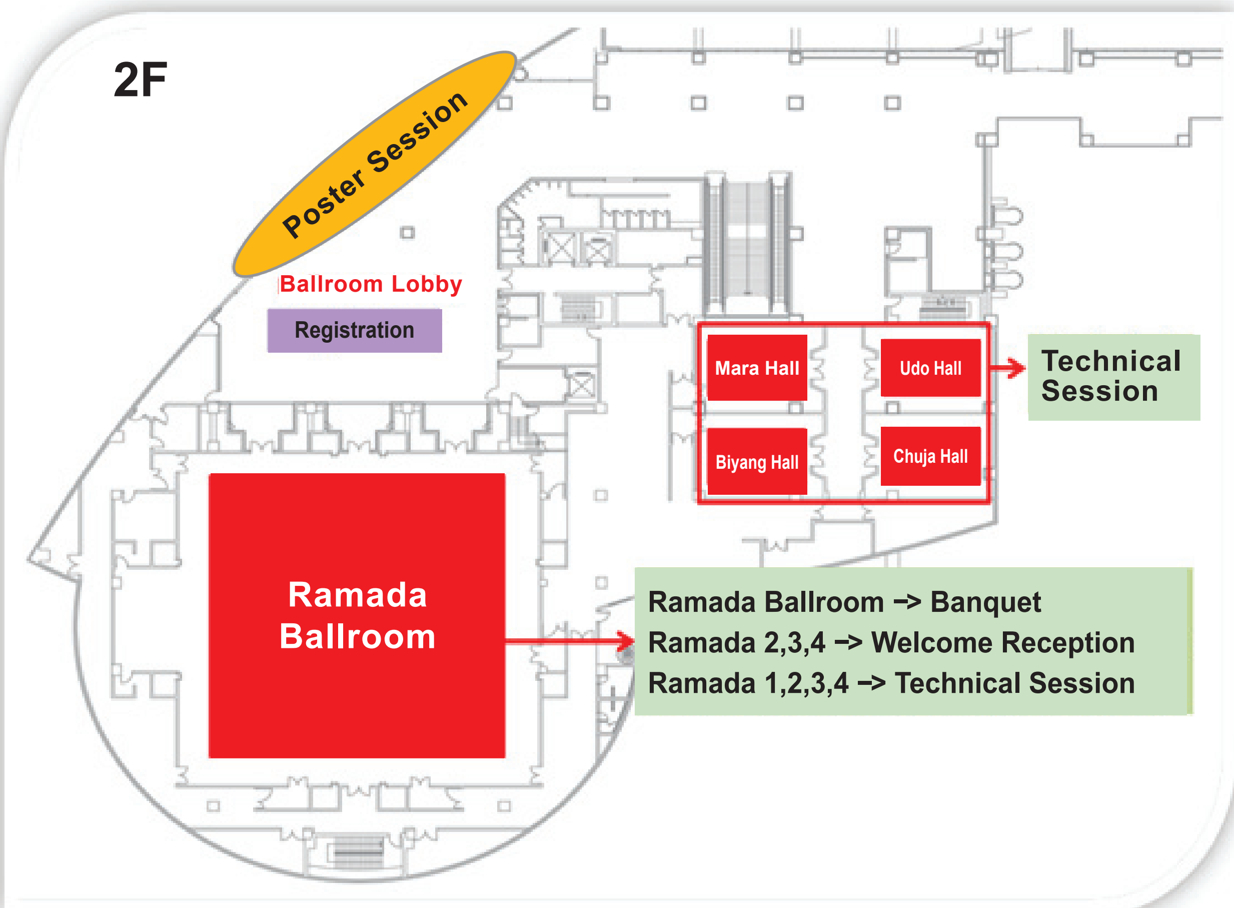
Oct 13 (Monday)									
08:00-17:00	**Registration**								
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-1**	**Ramada-2**	**Ramada-3**	**Ramada-4**	**Halla(8F)**
08:30-10:10	**Technical sessions MA**								
	MA1	**MA2**	**MA3**	**MA4**	**MA5**	**MA6**	**MA7**	**MA8**	**MA9**
Session name	Data Mining 1	Management of Technology and Innovations 1	ERP/ E-Business	Service Sciences 1	Quality Engineering & Management 1	Production and Operations Management 1	Metaheuristics	Financial Models & Engineering	Uncertainty Theory (Session I)
Paper #	**528**	**100**	**37**	**54**	**23**	**75**	**42**	**41**	**551**
	207	**111**	**38**	**55**	**28**	**158**	**43**	**146**	**555**
	276	**143**	**352**	**108**	**109**	**211**	**175**	**180**	**556**
	324	**44**	**360**	**215**	**113**	**269**	**353**	**267**	**584**
	296	**97**	**255**	**244**	**226**	**213**	**465**	**273**	
10:10-10:30	**Coffee break**								
10:30-11:00	**Opening addresses: APIEMS President, KIIE President, General Chair**								
11:00-12:00	**Keynote speech I (Prof. Chung-Yee Lee: Research Issues in Future Logistics)**								
12:00-13:30	**Lunch**								
13:30-15:30	**Technical sessions MB**								
	MB1	**MB2**	**MB3**	**MB4**	**MB5**	**MB6**	**MB7**	**MB8**	**MB9**
Session name	Decision Support Systems & Expert Systems	Probability & Statistical Modeling	Ergonomics/ Human Factors 1	Service Sciences 2	Quality Engineering & Managment 2	Production and Operations Management 2	Green Manufacturing/ Management	Transportation	Ergonomics & Welfare Management
Paper #	**173**	**190**	**96**	**322**	**227**	**338**	**417**	**73**	**488**
	254	**299**	**131**	**401**	**228**	**362**	**550**	**91**	**484**
	290	**333**	**305**	**411**	**229**	**394**	**119**	**103**	**530**
	460	**334**	**315**	**479**	**346**	**396**	**156**	**312**	**485**
	116	**3354**	**326**	**504**	**294**	**442**	**342**	**340**	**471**
	538	**450**	**332**	**323**	**307**		**361**	**53**	**505**
15:30-15:50	**Coffee break**								
15:50-17:50	**Technical sessions MC**								
	MC1	**MC2**	**MC3**	**MC4**	**MC5**	**MC6**	**MC7**	**MC8**	**MC9**
Session name	Supply Chain Management 1	Reliability & Maintenance	Ergonomics/ Human Factors 2	Network Optimization	Quality Engineering & Management 3	Simulation 1	Healthcare Systems 1	Optimization Techniques 1	Educational Support System
Paper #	**252**	**118**	**456**	**407**	**325**	**500**	**482**	**374**	**501**
	261	**121**	**359**	**363**	**328**	**196**	**99**	**217**	**562**
	279	**153**	**393**	**268**	**339**	**424**	**112**	**201**	**448**
	280	**320**	**419**	**515**	**346**	**66**	**194**	**169**	**455**
	355	**580**	**449**	**319**	**370**	**179**	**248**	**206**	**154**
	336	**582**	**341**	**142**	**402**			**271**	**507**

Oct 14 (Tuesday)									
08:00-17:00	**Registration**								
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-1**	**Ramada-2**	**Ramada-3**	**Ramada-4**	**Halla(8F)**
08:40-10:40	**Technical sessions TA**								
	TA1	**TA2**	**TA3**	**TA4**	**TA5**	**TA6**	**TA7**	**TA8**	**TA9**
Session name	Supply Chain Management 2	Communication Support	Data Mining 2	Tourism Management/ Topics in IE/MS	Sustainable Management	Simulation 2	Production & Operations Management 1	Logistics Management	Uncertainty Theory (Session II)
Paper #	**50**	**443**	**128**	**472**	**35**	**98**	**282**	**440**	**558**
	59	**535**	**147**	**444**	**114**	**105**	**327**	**477**	**559**
	60	**489**	**203**	**564**	**136**	**221**	**349**	**483**	**560**
	61	**536**	**392**	**15**	**137**	**272**	**431**	**543**	**561**
	130	**480**	**412**	**264**	**291**	**295**	**104**	**344**	**565**
	161	**537**	**216**	**225**	**347**	**356**	**218**	**313**	**428**
10:40-11:00	**Coffee break**								
11:00-12:00	**Keynote speech II (Prof. Ronald Askin: Data Driven Decision Making in Manufacturing)**								
12:00-13:00	**Lunch**								
13:00-14:00	**Keynote speech III (Prof. Sungzoon Cho: Big Data Management)**								
14:00-14:20	**Coffee break**								
14:20-16:00	**Technical sessions TB**								
	TB1	**TB2**	**TB3**	**TB4**	**TB5**	**TB6**	**TB7**	**TB8**	**TB9**
Session name	Supply Chain Management 3	Management of Technology and Innovations 2	Data Mining 3	Scheduling & Sequencing 1	Knowledge & Information Management	Production & Operations Management 2	Healthcare Systems 2	Flexible Manufacturing Systems	Topics in IE/MS
Paper #	**165**	**188**	**437**	**122**	**250**	**49**	**95**	**579**	**575**
	176	**425**	**469**	**233**	**278**	**124**	**106**	**48**	**354**
	208	**317**	**486**	**284**	**445**	**151**	**306**	**62**	**378**
	160	**150**	**502**	**287**	**297**	**187**	**379**	**286**	**212**
	234	**22**	**581**	**309**	**389**	**12**	**76**	**457**	**202**
16:00-16:20	**Coffee break**								
16:20-18:00	**Technical sessions TC**								
	TC1	**TC2**	**TC3**	**TC4**					**TC9**
Session name	Heuristics/Metaheuristics	Inventory Modeling / Artificial Intelligence	Artificial Intelligence	Scheduling & Sequencing 2					Lean Production Management
Paper #	**70**	**381**	**182**	**399**					**542**
	464	**123**	**260**	**405**					**546**
	481	**101**	**490**	**418**					**94**
	520	**318**	**391**	**398**					**545**
	192		**499**	**79**					**547**
13:00-18:00	**POSTER Session**								
Paper #	**47**	**149**	**166**	**204**	**220**	**245**	**253**	**265**	**205**
	365	**366**	**382**	**400**	**414**	**422**	**432**	**435**	**524**
	451	**473**	**487**	**522**	**527**	**491**	**420**	**145**	
18:30-21:00	**General Reception**								

Oct 15 (Wednesday)								
08:00-12:00	**Registration**							
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-3**	**Ramada-4**	**Ramada-1**	**Ramada-2**
08:30-10:10	**Technical sessions WA**							
	WA1	**WA2**	**WA3**	**WA4**	**WA5**	**WA6**		
Session name	Inventory Modeling & Management	SCM and Forecasting 1	Production Design & Management 1	Scheduling & Sequencing 3	Fuzzy Logic	Optimization Techniques 2		
Paper #	**65**	**92**	**117**	**85**	**30**	**125**		
	80	**31**	**162**	**120**	**58**	**69**		
	71	**34**	**198**	**177**	**224**	**288**		
	446	**32**	**222**	**316**	**576**	**577**		
	518	**102**	**249**	**509**		**415**		
10:10-10:30	**Coffee break**							
10:30-12:10	**Technical sessions TB**							
	WB1	**WB2**	**WB3**	**WB4**	**WB5**	**WB6**		
Session name	Industrial Engineering Education	SCM and Forecasting 2	Production Design & Management 2	Scheduling & Sequencing 4	Quality Engineering & Reliability	Lean Manufacturing		
Paper #	**526**	**52**	**283**	**329**	**453**	**129**		
	139	**36**	**348**	**46**	**508**	**371**		
	256	**87**	**350**	**403**	**270**	**553**		
	495	**413**	**93**	**426**	**517**	**110**		
			84	**454**	**421**	**516**		
12:10-13:30	**Lunch**							

Floor Plan


8F
Tamna Hall
Halla Hall
Technical Session(10/13~14)
Ara Hall
Ora Hall


2F
Poster Session
Ballroom Lobby
Registration
Mara Hall
Udo Hall
Biyang Hall
Chuja Hall
Technical Session
Ramada Ballroom
Ramada Ballroom -> Banquet
Ramada 2,3,4 -> Welcome Reception
Ramada 1,2,3,4 -> Technical Session

to understand the contents of the story by the hearing impaired students to see the mouth of the speaker of the panoramic image. By using our system, the hearing impaired student can understand what a speaker says.

Keywords: Hearing impaired student, Lip motion, Active learning, Panoramic camera

■ MB9-5(471)

Approach of Health-care Administration Utilizing Purchase Data of School Cafeteria

* Shoji Takechi
Department of Management Systems, Kanazawa Institute of Technology, Japan

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This article deals with a case study of the activities for dietary education and improvement based on the highly developed information technology. The activities includes data analysis of large-sized purchase data of the school cafeteria, field investigations, questionnaire surveys and campaign for healthy diet. First, we analyzed more than one hundred thousand purchase data of customers of "a la carte" style cafeteria with over two hundred kinds of supplied dishes during a half of year, and we found the eight clusters about customer's purchase type. Next we analyzed the nutritional intakes of individual purchases and compared the requirements of each nutrient. As results, we found the customers generally had deficient nutrients such as calcium, iron, fiber and some kinds of vitamins, but the customers also had excess nutrients such as fat and salt. Then we conducted the field investigations, and got questionnaires on nutritional knowledge and behavioral selection to survey the reason of the bad balanced nutrients of meals. From the answers of questionnaires, we found that some customers had poor knowledge about well-balanced nutrients of meals. Therefore we launched an awareness campaign for healthy diet in the cafeteria. We displayed some posters showing well-balanced nutrients of meals in the cafeteria area, and provided an application service via cellular phones to check the nutritional intakes of the selected dishes with fun. These campaign suggested the insufficient kinds of nutrients, and promoted to purchase an additional and optimal dish containing the insufficient nutrients.

Keywords: Data mining, Dietary improvement, Healthcare, Purchase data, Service Engineering

■ MB9-6(505)

Recognition of the Distance between Plant and Human by Plant Bioelectric Potential

* XINGYI JIN[1], Hidetaka Nambo[2], Haruhiko Kimura[2]
[1] Graduate School of Natural Science & Technology, Kanazawa University, Japan
[2] Collage of Science and Engineering, Kanazawa University, Japan

E-mail : xingyi1123@gmail.com

In this paper, we consider the method to recognize the distance between plant and human by plant bioelectric potential. In previous study, it is reported that plant bioelectric potential is affected by the environmental factors around plant. For example, temperature, humidity, atmospheric pressure, human behaviors and so on. In this study, we analyze the plant bioelectric potential when a human is doing walking motion in a place near the plant. It showed that different frequency distributions of plant bioelectric potential when a human is doing walking motion in different place, and the maximum distance to recognize walking motion is 2m. Therefore, we did some experiment about identification. We used FFT to extracting a characteristic from plant bioelectric potential, learning by Artificial Neural Network, and used 10-fold cross validation to do the distance recognition experiment. It shows that if we use one person's data to learning, the F-measure is very high. But when we use five persons' data to learning, the F-measure is getting lower. It means every person's characteristic from plant bioelectric potential is different.

Keywords: Plant bioelectric potential, Recognition of basic human behaviors, Sensory system

MC1 Supply Chain Management 1

Mara, Monday 15:50-17:50
Chair: Rainisa Heryanto
Maranatha Christian University, Indonesia
※ ________ : Presenter, * : Corresponding Author

■ MC1-1(252)

A Multi-Criteria Selection for Inventory Aggregation Problem under Risk Pooling: A Case Study

* Kanokporn Rienkhemaniyom, Nipa Suttachat
Graduate School of Management and Innovation, King Mongkut's University of Technology Thonburi, Thailand

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Inventory aggregation is one of risk pooling strategies that consolidates downstream demands in order to reduce the total demand variability (or demand risk) of a whole supply chain. It results in a lower inventory level across the whole supply chain. However, it also decreases the redundancy of the supply chain network due to the reduction in warehouse facilities. In other words, it increases the risk of supply chain disruption. In current business environment, where supply chain networks are vulnerable to disruptions from the increasing disruptive events, good supply chain networks should offer some promise of the resiliency when facing disruptions. Therefore, companies should consider the balance between the reduction in the demand risk and the increase in supply disruption risk. In this paper, we consider supply reliability as a measure of supply disruption risk criterion to evaluate multiple inventory aggregation alternatives, which are subjected to the change in number of distribution center. A case study of a consumer product company is used to demonstrate the tradeoffs between cost, customer responsiveness, and supply disruption risk. A multi-criteria selection framework is used to evaluate and rank the best inventory aggregation strategy.

■ MC1-2(261)

A Multi-Objective Closed-Loop Supply Chain Model For Multiple Generations of a Product with Mandatory Product Take-back

Justin Sison Contreras[1], * Dennis Espinosa Cruz[2]
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This study proposes a multi-objective mathematical model for a closed-loop supply chain of multiple generations of high technology products with mandatory product take-back, optimizing decisions on the introduction time of generations, production, purchasing, collection and recovery, under economic (i.e. Total profit) and environmental impact (i.e. Total emissions) objectives. The model considers the important link between the successive introduction of multiple generations to the demand quantity and to the quantity of available used products for collection. Current models assume that the levels of demand and used products are known parameters, but this model considers that the introduction of multiple generations prompts changes in the demand due to cannibalization, and changes in the quantity and quality of used products available due to changes in the consumption of the customers such as generation upgrades. A mandatory product take-back program is also included in the model to analyze its effect on the MGP strategy. The model was validated with test parameters. Weighted goal programming was used as the multi-objective approach, and different scenarios were tested for analysis. A common course of action over the scenarios is to have an earlier introduction and later a discontinuation of generations to extend the selling time when the conditions are favorable (e.g. low recycling target, low costs, low emissions), and the opposite when the conditions are unfavorable.

■ MC1-3(279)

The Proposal of Applying Multi Echelon Inventory to Minimize Supply Chain Total Cost for Soft Drinks

* Santoso - -, Rainisa Maini Heryanto
Industrial Engineering, Maranatha Christian University, Indonesia

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Inventory management in a supply chain system was an important factor to be considered. Well managed inventory would have a positive impact to meet demand and especially to minimize supply chain total costs to be incurred by the company. A supply chain usually consists of production and distribution of products between entities that were interconnected with each other.
In this study would be discussed how the integration between entities in a supply chain of soft drink products using three echelon concept includes echelon production consists of one plant, echelon distribution center which was spread across in six different areas, and echelon outlet for each distribution center. The model used and could represent the real condition that occurs was a model of Bahagia (1999) which used a heuristic approach to find the optimal solution. There were three flavors of soft drinks which produced by the plant that could be categorized into one product family. Before applying the multi echelon inventory concept, first step was forecasting demand for the future and aggregation process. The integration after aggregation process was the implementation of single cycle policy with the final goal to be achieved were the fulfillment of future demand and minimize supply chain total costs. The supply chain costs included the plant total cost, distribution center total cost, and outlet total cost.

Keywords: echelon, supply chain, total cost

■ MC1-4(280)

The Improvement of the Model of Wheat Flour Requirement at Eastern Indonesia by Determining the Number Location of the New Plant

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Wheat flour was one alternative that became basic ingredient of food for the household sector and even large industrial enterprises to small business units. The increasing number of people also was followed by the increasing of per capita Indonesian consumption of wheat flour and if it wasn't followed by the increasing in the number of production there would be shortage of wheat flour in the future.
In the current condition, the needs of national wheat flour can be met by existing local producers and assisted with import. The number of plants was very low at Eastern Indonesia that was only one small plant that might not meet the demand of wheat flour for that region, while demand would increase from year by year. Therefore, if it wasn't followed by building of new plant at Eastern Indonesia, the shortage of wheat flour will be met by supply from Western Indonesia or import.
The model that was developed in this research used research approach by Y Hinojasa, et al (2000) and Fulya Altiparmak, et al (2007). The first model tried to meet the demand for consumer products in vary locations based on the criteria of the smallest total cost. The second model tried to determine the set of facilities that would be opened and made the distribution network design to meet the demand of consumers based on the smallest total cost. The result was the determination of the number and location of the new wheat flour plant based on the supply chain total cost minimization which included plant total cost, depot total cost, and transportation total cost. The calculation of transportation total cost used research approach which was developed by Archetti, et al (2006) and then determined the distribution route of wheat flour by using the split delivery vehicle routing problem.

■ MC1-5(355)

Coordination of supply chains with risk-averse members under budget constraints

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Risk-averse preference and budget constraints are commonly considered in real decision frameworks; however, the supply chain contract literature has not addressed the contract design for supply chains with risk-averse members who have budget constraints. This paper studies a revenue-sharing-and-sales-rebate (RSSR) contract that combines two subcontracts: a revenue-sharing (RS) contract and a sales-rebate (SR) contract for a two-stage supply chain with a risk-averse retailer and a risk-averse manufacturer that have budget constraints. We study supply chain coordination in two commonly used decision frameworks: risk in the utility function and risk in the constraints. First, we demonstrate that some optimal decision rules with risk-averse members are no longer optimal when we consider the budget constraints. Next, this article discusses how the RS, extended RS (ERS), and RSSR contracts work to coordinate the supply chains with risk-averse members under budget constraints. We show the limitations of ERS contract and why the RSSR contract is more appropriate in many cases. We identify three regions of the budget space based on the performances of the RS, ERS, and RSSR contracts. Our analytical and numerical results lend insights into how the managers select an appropriate contract based on their risk-averse preferences and budget scenario.

The Proposal of Applying Multi Echelon Inventory to Minimize Supply Chain Total Cost for Soft Drinks Products

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Abstract. Inventory management in a supply chain system was an important factor to be considered. Well managed inventory would have a positive impact to meet demand and especially to minimize supply chain total costs to be incurred by the company. A supply chain usually consists of production and distribution of products between entities that were interconnected with each other.

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1. INTRODUCTION

In general often found a supply chain system was still not integrated between each of the entities that exist in it. There wasn't a good flow of information between entities ultimately made consumer demand could not be met and the total cost to be incurred by each entity became expensive. This problem which was being faced by a supply chain of soft drink products in Indonesia. Soft drink product supply chain system consists of three echelons, the echelon production consist of one plant, the second echelon was echelon distributions center that consist of six distribution center (n > 1), each distribution center was spread over six different area, and the third echelon was echelon outlet that sold products to consumers. The area of echelon outlet was same as the area of distribution center but located at the different location. The supply chain system of soft drink product was shown in Figure 1.

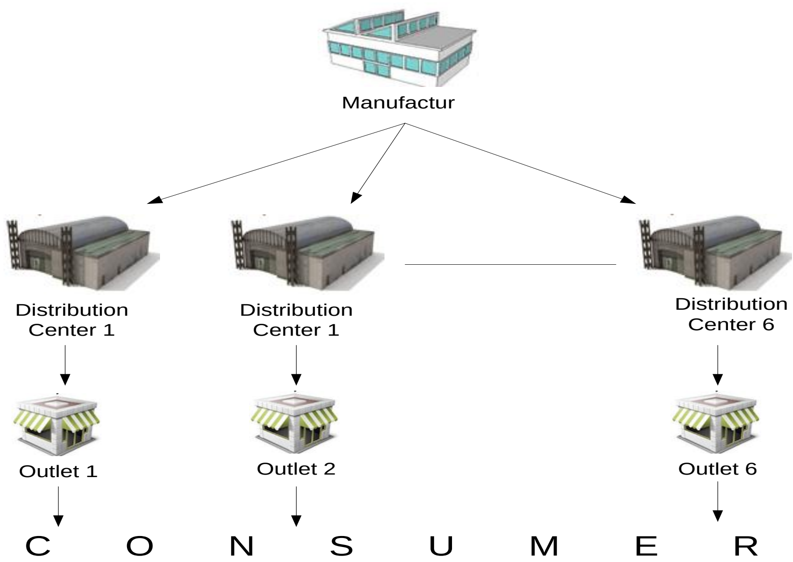

Figure 1: Supply Chain System

Plant had function as echelon production that supply soft drink product to distribution center in accordance with the demand. Distribution center had function to accommodate the production of soft drink product and supply of it to outlet. Outlet was the echelon that works to supply the end customer and receiving supplies from the distribution center. Each outlet could only be supplied by a single source was the distribution center and the soft drink products of the outlets were not allowed to move to other outlets. Demand of soft drink products from consumer to the outlets followed a normal distribution.

This study was tried to integrate every echelon in the supply chain system. Through integration expected all soft drink demand in the future could be met and to minimize supply chain total cost that included plant total cost, distribution center total cost, and outlet total cost.

2. METHODOLOGY

The integration was doing in this study using the basic model of Bahagia (1999) by applying a single cycle time policy, which at a certain moment, all the entities in a supply chain system started doing production or order simultaneously. The difference with the model of Bahagia (1999) was in the number of members at each echelon, the basic model consisted of one echelon production, one echelon depot, and ten echelon retailers.

Each outlet had a demand from consumers and then outlets accommodate all the requests and order to the distribution center. Each echelon distribution center only distribute soft drink products to the outlet so that the number of requests at the outlet would be equal to the number of requests at the distribution center. Similarly, each of distribution center had demand from each outlet and order to the plant, so that plant had the demand of each distribution center. Total demand at the plant was the sum of the demand of each echelon distribution center.

The problem that occurs was the order size made by the outlet to the distribution center has not been right so often there was a shortage or surplus soft drink products. To overcome this, first step was forecasting total demand for each individual flavor and size of soft drinks. Soft drinks were produced consists of 3 flavors which each flavor packaged in 3 different sizes. So that, forecasting was done by forecasting for the product family, where each flavor demand was forecasted and then aggregated into a single product.

After family forecasting process, the next step was calculating the supply chain total cost by implementing a single cycle time policy. A single cycle time was the time cycle in which there were certain times (at the beginning or at the end) the cycle time of all entities/subsystems that exist within a value chain system would place an order or initiate production/ordering products at the same time. A single cycle policy was shown in Figure 2.

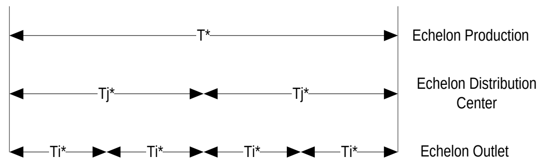

Figure 2: A Single Cycle Policy

2.1 Model Component

2.1.1 Problem and Decision Variable

The problem which was modeled in this study was the integration of every echelon of the supply chain system to minimize the supply chain total cost that included the plant total cost, the distribution centers total cost, and the outlet total cost.

Decision variable in every echelon:

a. At outlet i
   Q_i = ordering size from outlet i to distribution center j (CS)

b. At distribution center j
   Q_j = ordering size from distribution center j to plant (CS)

c. At plant
   Q_m = production size (CS)

2.1.2 Performance Criteria

Performance criteria used in this model was minimizing the total cost of the supply chain. The cost of the supply chain consisted of the sum of the total expected cost of the plant, the total expected cost of the distribution center, and the total expected cost of outlet. In the model developed, the performance criterion was expressed as a objective function.

2.1.3 Limitation and Assumption

Limitation for this research:

1. The pattern of future data followed the pattern of past data.
2. Outlets and distribution center located at the same area but a different location.

Assumption for this research:

1. Soft drink demand at outlet i followed normal distribution and could only be served by distribution center j where i = j
2. Lead time less than ordering cycle
3. Unserve soft drink demand by outlet i would lost (lost sales)
4. Soft drink products at outlet i and distribution center j could not be transferred to another outlet (non trasferable)
5. Ordering cost was constant in every ordering
6. Service level at outlet i was determined by each outlet
7. Shortage cost comparable with amount of unserved soft drink demand and holding cost comparable with the amount of stored soft drink product during storage time.

3. MATHEMATICS

Mathematical model was used to calculate the supply chain total cost divided into 3, outlet total cost, distribution center total cost, and plant total cost.

3.1 Mathematics Notations

Index Notation

i = outlet index (i = 1, 2, … 6)
j = distribution center index (j = 1, 2, … 6)

Parameter Notation

For forecasting

CV = Coefficient of Variance
μ = average past demand
σ = standar deviation past demand
MSE = Mean Square Error
n = number of past period

At outlet

L_{ij} = lead time from distribution center j to outlet i (year)
D_i = annually demand at outlet i (CS)
SS_i = safety stock at outlet i (CS)
C_i = total operating cost for outlet i (IDR/year)
A_i = ordering cost from outlet i to distribution center j (IDR/order)
H_i = holding cost at outlet i (IDR/CS/year)
B_i = shortage cost at outlet i (IDR/CS)
M_i = number of shortage at outlet i (CS/year)
R_i = minimum inventory at outlet i (CS)
T_i* = length of one cycle at echelon outlet (year)

At distribution center

L_{mj} = lead time from plant to distribution center j (year)
D_j = annually demand at distribution center j (CS) = D_i
C_j = total operating cost for distribution center j (IDR/year)
A_j = ordering cost from distribution center j to plant (IDR/order)
H_j = holding cost at distribution center j (IDR/CS/year)
R_j = minimum inventory at distribution center j (CS)
Tj* = length of one cycle at echelon distribution center (year)

At plant

D_m = annually demand at plant

$$= \sum_{j=1}^{6} D_j$$

A_m = setup cost at plant (IDR/setup)
C_j = total operating cost for plant (IDR/year)
H_j = holding cost at plant (IDR/CS/year)
R_m = minimum inventory at plant (CS)
T* = length of one cycle at echelon production (year)

3.1.1 Forecasting

The forecasting process began by calculating Coefficient of Variance (CV) value with formulation:

$$CV = \frac{\sigma}{\mu} \quad (1)$$

To find the forecasting method that could be used to forecast future demand, necessary calculation of Mean Square Error (MSE). The best method was a method that had the smallest MSE. MSE calculation using the formula:

$$MSE = \frac{\sum_{i=1}^{n}(dt - dt')^2}{n} \quad (2)$$

3.1.2 Cost at Echelon Outlet

Outlet policy consist of:

a. Order size at outlet i (Q_i) which have constant value in every ordering
b. Outlet i would order to distribution j (where i = j) if inventory level reached R_i with formulation:

$$R_i = L_{ij}\, D_i + SS_i \quad (3)$$

Total cost at every outlet (C_i) was sum of ordering cost, holding cost, and shortage cost with formulation:
C_i = ordering cost + holding cost + shortage cost

$$C_i = A_i \frac{D_i}{Q_i} + H_i\left(\frac{Q_i}{2} + SS_i\right) + \left(B_i\, M_i \frac{D_i}{Q_i}\right) \quad (4)$$

3.1.3 Cost at Echelon Distribution Center

Distribution center policy consist of:

a. Order size at distribution center j (Q_j) which have constant value in every ordering
b. Distribution center j would order to plant if inventory level at distribution center j reached Rj with formulation:

$$R_j = (L_{mj} + L_{ij})\, D_i + SS_i \quad (5)$$

Total cost at every distribution center (C_j) was sum of ordering cost and holding cost at echelon distribution center with formulation:

C_j = ordering cost + holding cost

$$C_j = A_j \frac{D_j}{Q_j} + H_j\left(\frac{Q_j}{2} + L_{ij}\, D_j + SS_i\right) \quad (6)$$

3.1.4 Cost at Echelon Production

Plant policy consist of:

a. Production lot size (Q_m) which have constant value in every production cycle
b. Production did if inventory level at echelon production reached R_m with formulation:

$$R_m = \sum_{i=1}^{6}\left(\frac{Q_j}{K} + L_{mj} + L_{ij}\right) D_i + SS_i \quad (7)$$

Total cost at plant (C_m) was sum of setup cost and holding cost at echelon production using the formula:

$$C_m = A_m \frac{D_m}{Q_m} + H_m \left\{ \sum_{j=1}^{6}\sum_{i=1}^{6}\left(\frac{Q_m}{K} + L_{mj} + L_{ij}\right) D_i + \left(1 - \frac{D_m}{K}\right)\frac{Q_m}{2} + SS_i \right\} \quad (8)$$

3.2 Objective Function and Constraint

Objective function in this research was minimize supply chain total cost (C) which consist of the sum of expected outlet total cost (C_i), expected distribution center total cost (C_j), and expected plant total cost (C_m) with formulation:

Minimize $C = C_i + C_j + C_m$

By mathematics formulation:
Minimize C =

$$\sum_{i=1}^{6}\left\{A_i \frac{D_i}{Q_i} + H_i\left(\frac{Q_i}{2} + SS_i\right) + \left(B_i\, M_i \frac{D_i}{Q_i}\right)\right\} +$$

$$\sum_{j=1}^{6}\left\{A_j \frac{D_j}{Q_j} + H_j\left(\frac{Q_j}{2} + L_{ij}\, D_j + SS_i\right)\right\} +$$

$$A_m \frac{D_m}{Q_m} + H_m \left\{ \sum_{j=1}^{6}\sum_{i=1}^{6}\left(\frac{Q_m}{K} + L_{mj} + L_{ij}\right) D_i + \left(1 - \frac{D_m}{K}\right)\frac{Q_m}{2} + SS_i \right\} \quad (9)$$

Constraint:

a. Number of demand:

$$D_m = \sum_{j=1}^{6} D_j = \sum_{i=1}^{6} D_i$$

b. Single cycle policy:

$$T^* = \frac{Q_m}{D_m} = N_{mj} \frac{Q_j}{D_j} = N_{mj} N_{ij} \frac{Q_i}{D_i}$$

c. Q_m, Q_j, and $Q_i \geq 0$

d. N_{mj} and $N_{ij} \geq 1$, integer

3.3 Model Solution

If constraint (a) and (b) were substituted to mathematics formulation, so:

Minimize C =

$$\sum_{i=1}^{6} \left\{ \left(A_i + B_i M_i \right) \frac{D_m}{Q_m} N_{mj} N_{ij} + H_i \left(\frac{D_i Q_m}{2 D_m N_{mj} N_{ij}} + SS_i \right) \right\} +$$

$$\sum_{j=1}^{6} \left\{ A_j \frac{D_m}{Q_m} N_{mj} + H_j \left(\frac{D_j Q_m}{2 D_m N_{mj}} + L_{ij} D_j + SS_i \right) \right\} +$$

$$A_m \frac{D_m}{Q_m} + H_m \left\{ \sum_{j=1}^{6} \sum_{i=1}^{6} \left(\frac{Q_m}{K} + L_{mj} + L_{ij} \right) D_i + \left(1 - \frac{D_m}{K} \right) \frac{Q_m}{2} + SS_i \right\} \quad (10)$$

Optimal Q_m* value was reached if $\frac{dC}{dQ_m} = 0$

so Q_m* was reached with formulation:

$$Q_m^* = \sqrt{\frac{2 D_m \left(\sum_{i=1}^{6} (A_i + B_i M_i) N_{mj} N_{ij} + \sum_{j=1}^{6} A_j N_{mj} + A_m \right)}{H_m \left(1 - \frac{D_m}{K} + \sum_{i=1}^{6} \frac{2 D_i}{N_{mj} K} \right) + \left(\sum_{i=1}^{6} \sum_{j=1}^{6} \frac{H_i D_i}{D_m N_{mj} N_{ij}} \right) + \left(\sum_{j=1}^{6} \frac{H_j D_j}{D_m N_{mj}} \right)}} \quad (11)$$

The above mathematical model was convex function so that the solution given by the model was a local minimum solution. It could be seen from the second derivative was positive.

To find Qm* value, N_{mj} and N_{ij} value was needed. Based on Bahagia basic model (1999), that value was obtained by heuristic approach and assumed that N_{mj} and N_{ij} value was continue number. Ordering frequency from each outlet to distribution center (N_{ij}) in one cycle (T*) was minimum integer number which follow:

$$N_{ij} (N_{ij} + 1) \geq \frac{A_j H_i D_i}{\left(D_m (H_j + 2 H_m \frac{D_m}{K})(A_i + M_i B_i \right)} \quad (12)$$

$$\frac{A_j H_i D_i}{\left(D_m (H_j + 2 H_m \frac{D_m}{K})(A_i + M_i B_i \right)} = k_i$$

4. RESULT AND DISCUSSION

For the problem that occurred at supply chain for soft drink product, data at echelon production, echelon distribution center, and echelon outlet were shown at Table 1, Table 2, and Table 3. Demand at every outlet i was obtained from forecasting result for one year later.

Based on CV calculation from each flavor demand, it was obtained that CV value > 0.2 mean that non stasioner data. Method which used for forecasting future demand for non stasioner data consisted of 7 method were linear, cyclical, linear cyclical, Double Exponential Smoothing, Double Exponential Smoothing with Trend, Double Moving Average, and Holt Winter Algorithm.

From that methods, it was chosen one best method for forecasting future demand based on the smallest Mean Square Error (MSE) criteria. Chosen method for flavor A and flavor B were cyclical, and for flavor C was linear cyclical.

Q_m* value (optimal size production) at echelon production from calculation result was 111,426 CS. From Q_m* result could be calculate that single cycle time at echelon production was 0,05 year or 15 days. At 1 horizon planning (1 year) there were 20 production cycle.

Because of every outlet i could be served by outlet j where i = j, so annually demand at outlet would be same as annually demand at distribution center, N_{mj} value which gave minimum supply chain total cost was same as with N_{ij} value. Based on formulation (12) was reached N_{ij} value for each i. The same value between N_{ij} and N_{mj} caused Q_j and Q_i had the same value too.

After obtained ordering size, aggregate process was done to calculate ordering size each flavor based on proportion. Calculation result was shown at Table 4. Total cost result and comparison of supply chain total cost before and after integration was shown at Table 5. From the result comparison result, the plant total cost with integration was smaller than the plant total cost individual (without integration), but the distribution total cost and outlet total cost with integration was larger that without integration. But overall, the supply chain total cost with integration was smaller than individual (without integration).

Table 1: Data at Echelon Production

Information	Symbol	Dimension	Value
Production Capacity	K	CS/year	4,860,000
Setup Cost	Am	IDR/setup	15,000,000
Holding Cost	Hm	IDR/CS/year	4,800

Table 2: Data at Echelon Distribution Center

Information	Symbol	Dimension	Distribution Center					
			1	2	3	4	5	6
Ordering Cost	Aj	IDR/order	90,000	67,500	57,500	45,000	50,000	48,500
Holding Cost	Hj	IDR/CS/year	1,250	1,500	1,750	1,400	1,450	1,350
Demand	Dj	CS/year	636,745	318,373	530,621	212,248	106,124	424,497
Lead Time from Plant	Lmj	year	0.003	0.003	0.017	0.010	0.007	0.010

Table 3: Data at Echelon Outlet

Information	Symbol	Dimension	Outlet					
			1	2	3	4	5	6
Ordering Cost	Ai	IDR/order	32,500	22,500	27,500	23,500	24,500	30,000
Holding Cost	Hi	IDR/CS/year	900	750	700	850	825	900
Demand	Di	CS/year	636,745	318,373	530,621	212,248	106,124	424,497
Shortage Cost	Bi	IDR/CS	84,000	87,500	85,000	84,000	85,000	86,000
Lead Time from Distribution Center	Lij	year	0.003	0.003	0.003	0.003	0.003	0.003
Safety stock	SSi	CS/year	6,000	4,200	6,000	4,800	3,600	5,400

Table 4: Calculation Result

i = j	ki	Nij	Nmj	Qj = Qi (CS)	Flavor A (CS)	Flavor B (CS)	Flavor C (CS)
1	0.0020	1	1	31,837	3,547	14,400	13,890
2	0.0008	1	1	15,919	1,774	7,200	6,945
3	0.0008	1	1	26,531	2,956	12,000	11,575
4	0.0004	1	1	10,612	1,182	4,800	4,630
5	0.0003	1	1	5,306	591	2,400	2,315
6	0.0008	1	1	21,225	2,365	9,600	9,260

Table 5: Total Cost Comparison

Total Cost	Integration	Individu
Plant	1,685,374,445	3,495,971,215
Distribution Center	142,105,155	47,040,735
Outlet	234,110,858	34,033,000
Total Cost (IDR/year)	2,061,590,458	3,577,044,950

5. CONCLUSION

Based on calculation process, result, and discussion, it could be given some conclusion:

a. Basic model Bahagia (1999) could be used for helping integrated echelon at supply chain system for soft drink product.

b. Used model tried to find minimum supply chain total cost which consisted of plant total cost, distribution total cost, and outlet total cost.
c. The total cost with integration was smaller than the total cost individual without integration.

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Certification for Presenter

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We highly appreciate your contribution to the APIEMS 2014.

Sincerely yours,

Chi H. Jun

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