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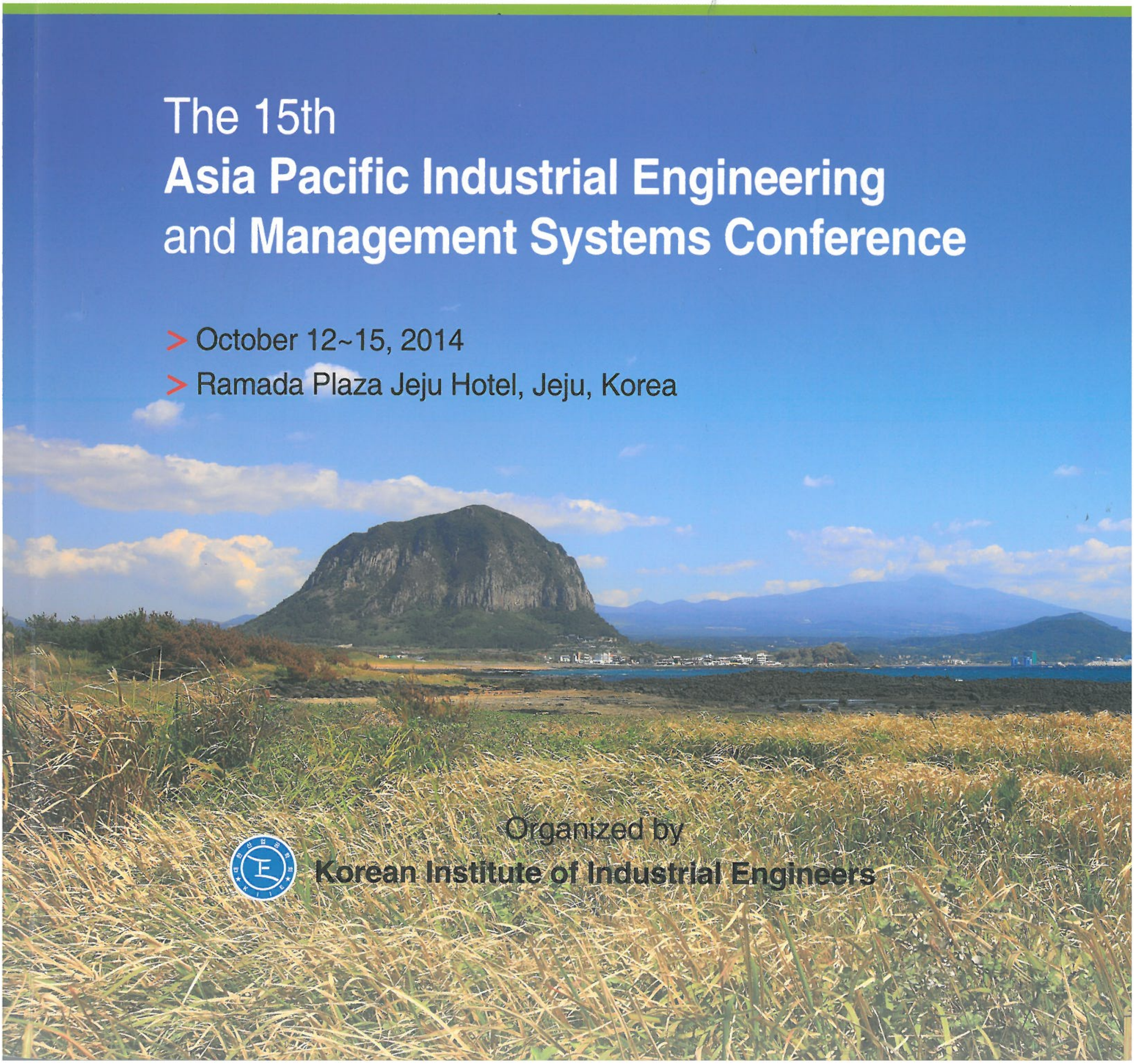
APIEMS

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

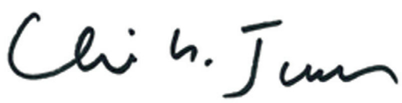
Dean, School of Engineering and Technology

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 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

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**

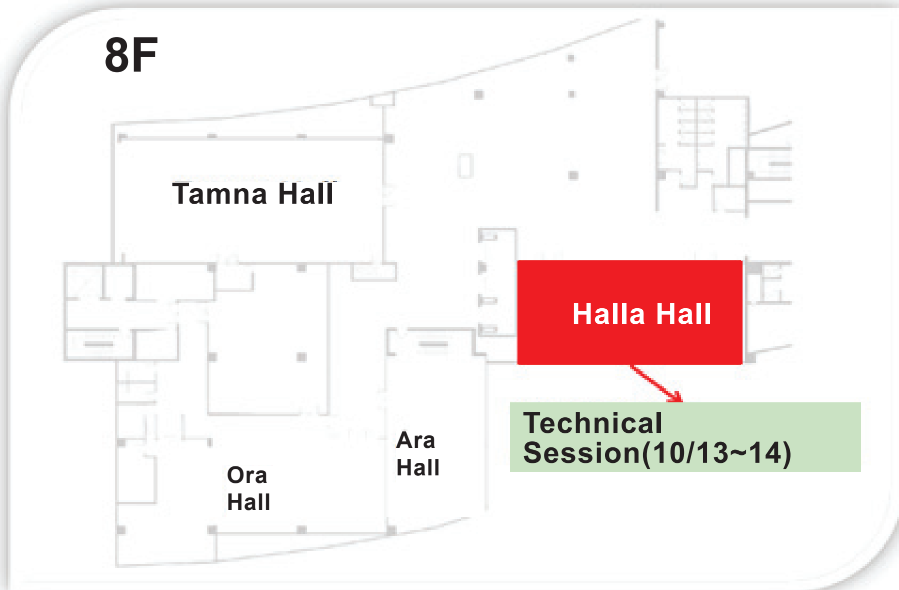
Oct 14 (Tuesday)

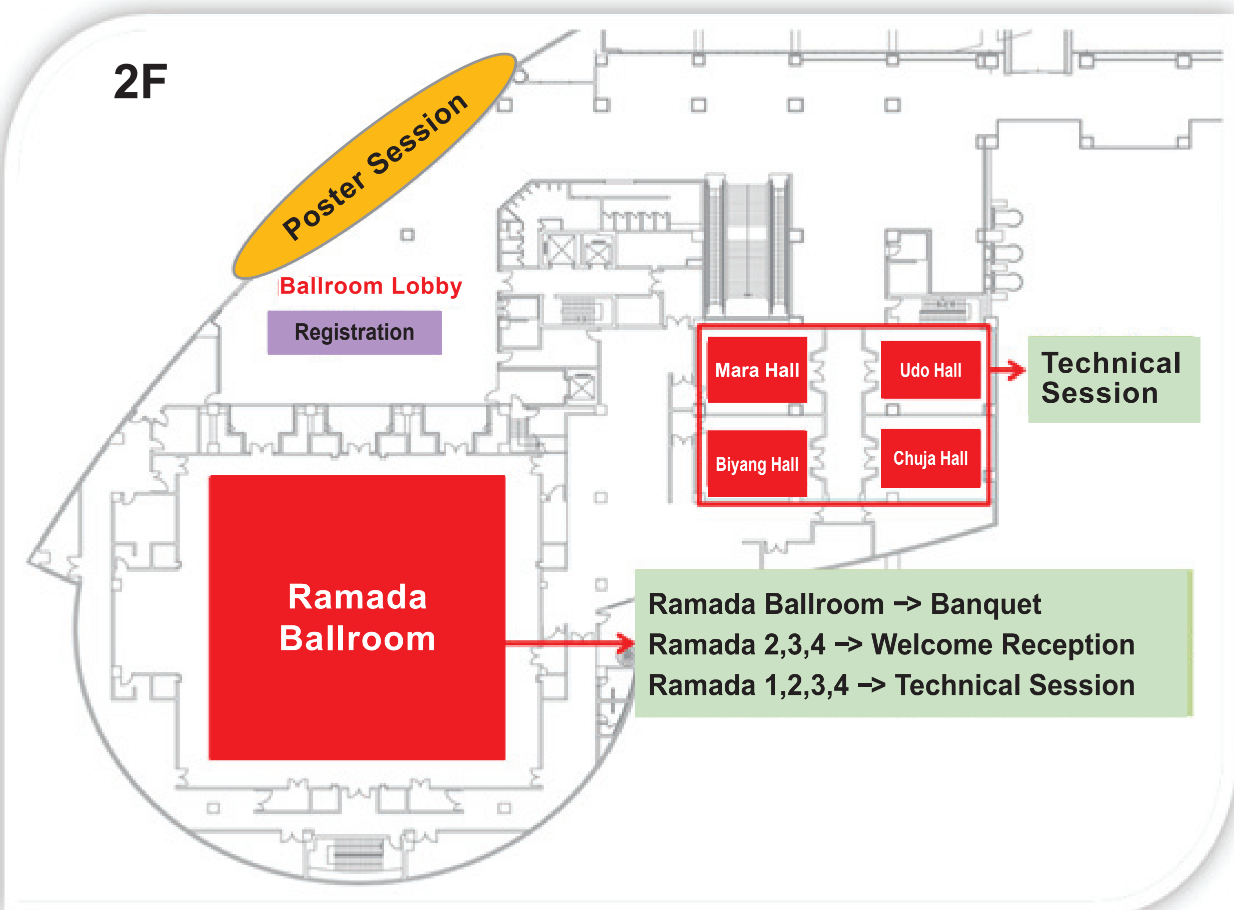
08:00-17:00	**Registration**								
Room	**Mara**	**Biyang**	**Udo**	**Chuja**	**Ramada-1**	**Ramada-2**	**Ramada-3**	**Ramada-4**	**Halla(8F)**
08:40-10:40	**Technical sessions TA**								
	TA1	**TA2**	**TA3**	**TA4**	**TA5**	**TA6**	**TA7**	**TA8**	**TA9**
Session name	Supply Chain Management 2	Communication 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

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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

E-mail : kanokporn.rie@kmutt.ac.th

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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[2] Industrial Engineering, De La Salle University, Philippines

E-mail : dennis.cruz@dlsu.edu.ph

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

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Abstract. 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.
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Keywords: wheat flour, plant location, supply chain total cost

1. INTRODUCTION

Wheat flour was one of the food commodities that currently became the basis not only for households, but also for a variety of business sectors ranging from large scale industry until small business units. The consumption of wheat flour were diverse and the increase in population also caused an increase in per capita consumption of wheat flour Indonesian society (Aptindo, 2009)

Indonesia's population was projected to continue to increase by an average rate of population growth reaches 1.49% per year (BPS, 2010). Based on the growth rate, the population of Indonesia until 2025 was predicted to reach 273.2 million and for Eastern Indonesia is predicted to reach 38.4 million people. Eastern Indonesia covering 12 provinces were spread across the island of Sulawesi (North Sulawesi, West Sulawesi, Central Sulawesi, Gorontalo, South East Sulawesi, and South Sulawesi), Nusa Tenggara Islands (Nusa Tenggara and East Nusa Tenggara Province), Maluku Islands (Maluku Province and North Maluku), and

Papua (Papua and West Papua).

The increasing population was followed by the increasing of the national consumption of wheat flour. Increasing consumption of wheat flour per capita Indonesia reached 17 kilograms per person per year in 2009 and this number was predicted to increase to 25.52 kg in 2025. Increasing consumption should also was followed by increasing production, based on data Aptindo 2009, there were 13 local manufacturers of wheat flour in Indonesia that were spread in various areas with a total production capacity of 8 million tonnes per year. With the increasing prediction of demand compared to the available national production capacity, there might be a shortage of wheat flour for some years later, especially for Eastern Indonesia. In eastern Indonesia today there was only one small plant of wheat flour.

Therefore, for Eastern Indonesia, if it was not followed by the addition of the number of producers in that region, then wheat flour demand for Eastern Indonesia wouldn't be able to be met, and if it was relied on the supply from Java Island it would affect the cost of procurement and transportation was expensive and caused the inflated of sales price.

This research would develope of models to meet the requirement of the national wheat flour for Eastern Indonesia in the future by determining the number and location of the new wheat flour plant at Eastern Indonesia and how the transportation route to fulfill the requirement which result the minimum total cost.

2. METHODOLOGY

Research methods associated with determining the number and location of plant was developed using three main models approach were Y Hinojasa, et al model (2000), Fulya Altiparmak, et al model (2007), and Archetti, et al model (2006). Y Hinojasa, et al model (2000) tried to meet the demand for consumer in vary locations based on the criteria of the smallest total cost and Fulya Altiparmak, et al model (2007) tried to determine the set of facilities that will be open and make the distribution network design to satisfy consumer demand based on the smallest total cost.

A third research approach was determining the distribution of wheat flour from the plant to the depot which was located at Eastern Indonesia. Research approach to determine this distribution using the method of the split delivery vehicle routing problem was developed by Archetti, et al (2006). This method was searching for the minimum total transportation cost from the direct shipping cost and sharing shipping cost. The determination of the sharing route delivery from the wheat flour plant to the depot using matrix saving method.

The development of the three models used in this study aims to determine the number and location of the new wheat flour plant by minimizing the total cost of the supply chain that includes the plant total cost, the depot total cost, and the transportation total cost. Each total cost was divided into cost elements in it. The plant total cost was the sum of the cost to operate the plant, production cost, and holding cost. While the depot total cost was the sum of the cost to operate the depot, the cost of throughput, holding cost, and shortage cost.

Schematically, the stages of development of a mathematical model to determine the location of the new plant and flour as well as the determination of the distribution of the constraints and assumptions used in the model was shown in Figure 1 below. To find the solution, the approach used was a single cycle time (T_k). 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.

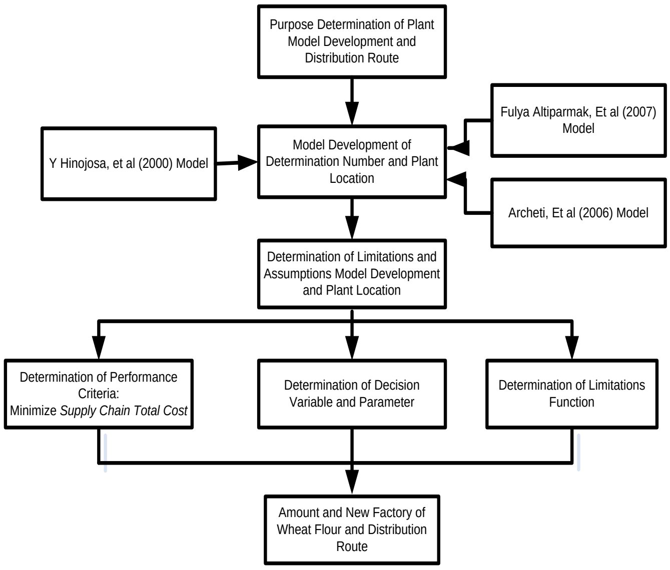

Figure 1: Model Development Stages

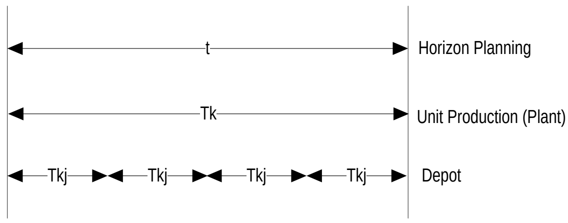

Figure 2: A Single Cycle Policy

2.1 Model Component

2.1.1 Problem and Decision Variable

The problem to be modeled in this study was the determination of the number and location of the new wheat flour plant at Eastern Indonesia. The determination of the inventory total cost using a calculation that occured in every aspect of the structural models of the production units and depots as well as the cost of transportation from the production unit to the depot.

In the model of determining the new location of the wheat flour plant, the decision variables in each structural aspects were:

a. At depot j:
   - T_{kj}^{t} = ordering cycle length depot j to plant k in period t (year)
   - R_{j}^{t} = maximum inventory at depot j in the ordering cycle in period t (kg)
   - ss_{j}^{t} = safety stock at depot j in period t (kg)

b. At unit production (plant) k:
   - T_{k}^{t} = production cycle length at plant k in period t (year)
   - R_{ok}^{t} = maximum inventory at plant k in period t (kg)
   - x_{k}^{t} = production size at the plant k in period t (kg/year)

$$z_k^t \begin{cases} 1 \text{ if plant k operate in period t} \\ 0 \text{ if plant k not operate in period t} \end{cases}$$

$$y_{kj}^t \begin{cases} 1 \text{ if plant k serve depot j in period t} \\ 0 \text{ if plant k not serve depot j in period t} \end{cases}$$

From the results of the decision variable depot and unit production then determined the transportation route can provide a minimum total cost of transportation. The decision variables in the calculation of the cost of transport were:

a. Number of trip for distribute product from plant k to depot j
b. Binary variable that decided whether a mode is used or not
c. Binary variable that decided whether a mode of visiting more than one depot or not

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 depot, and the total expected cost of transportation. In the model developed, the performance criterion was expressed as a objective function.

2.1.3 Limitation and Assumption

Limitation for this research:

1. Single cycle policy
   $T_k^t = n_j^t T_{kj}^t$
2. Length of production cycle greater than length of production time
   $T_k^t \geq m_{pk}$
3. Number of multiples was an integer and greater equal to 1
   $n_j^t \geq 1$ and integer
4. Each depot w visited only one mode of depot v
5. The vehicles come in a depot would come out at the same time (flow conservation)
6. The number of trips all the modes must be less than or equal to the number of depot which include at group delivery β_{ke}^t minus one *(subtours elimination)*
7. The number of delivered product using the vehicle b was not exceed its capacity
8. Vehicle started and ended at the plant

Assumption for this model:

1. Wheat flour demand at each depot j was normal distribution and the request could only be serviced by the manufacturer.
2. Demand at the plant was the sum of demand from depot which served by the plant.
3. The market could be competitive so that the unserved demand at a depot would be lost (lost sales).
4. Wheat flour at depot couldn't be transferred to other depots (non transferable).
5. What flour would flow from the production unit → depot →consumers.
6. Wheat flour demand just flew from consumers → depot → production unit.
7. The service level was determined by the results of calculations on the production units and depots.
8. Lead time was smaller than order cycle time.
9. Raw materials in the production units had been available at the start of production.
10. Ordering cost was constant, shortage cost comparable with the number of unserved wheat flour demand and holding cost comparable with the number of stored wheat flour during storage time.
11. Maintenance time in the plant was less than the length of the production cycle and the duration is 2 weeks (0.036 years).
12. Production rate greater than demand rate.
13. Machine efficiency for continuous production unit was 90%

3. MATHEMATICS

In the development of a mathematical model through the determination of new wheat flour plant location, the costs in the logistics systems of wheat flour were grouped into 3 parts, plant total cost expected, depot total cost expected, and transportation total cost expected, where each expectation had each cost components.

3.1 Mathematics Notation

Index Notation

j = index for depot (j = 1, 2 … W)
k = index for wheat flour plan (k = 1, 2, … M)
t = index for time (t = 1, 2, … T)

Parameter Notation

At plant k:

g_k^t = operating cost at plan k in period t (IDR/year)
A_k^t = setup cost at plant k in period t (IDR/kg production rate)
A_{pk}^t = machine maintenance cost at plant k in period t (IDR/maintenance)
v_k^t = production cost at plant k in period t (IDR/year)
p_k^t = production cost per kg at plant k in period t (IDR/kg)
h_k^t = holding cost at plant k in period t (IDR/year)
H_k^t = holding cost per kg at plant k in period t (IDR/kg)
m_{pk}^t = time production in one production cycle in period t (year)
m_k^t = time for machine maintenance at plant k in period t (year)
r_k^t = inventory position at plant k in the end of production cycle in period t (kg)
d_k^t = demand at plant k in period t (kg/year)
Q_{kj}^t = size to be sent by the plant k to depot j in first cycle (kg)
ψ_k = production rate at plant k (kg/year)
β_{ke}^t = shipping group from plant k in period t
af_{ke}^t = transportation cost from plant k in shipping group e (IDR/year)
apl_{ke}^t = direct shipping cost from plant k in shipping group e (IDR/year)
apb_{ke}^t = sharing shipping cost from plant k in shipping group e (IDR/year)
C_f = fix cost trip (IDR/mode)
C_d = shipping cost per km (IDR/km)
J_{kj} = distance from plant k to depot j (km)
J_{vw} = distance from depot v to depot w (km)
X_{bke} = number of sharing shipping group e from plant k
φ = mode capacity (kg)

At depot j:

o_j^t = total operating cost at depot j in period t (IDR/year)
A_{jk}^t = ordering cost at depot j to plant k in period t (IDR/order)
v_j^t = throughput total cost at depot j in period t (IDR/year)
p_{jk}^t = purchasing cost of wheat flour from depot j to plant k in period t (IDR/kg)
h_j^t = total holding cost at depot j in period t (IDR/year)
H_j^t = holding cost per kg at depot j in period t (IDR/kg)
d_j^t = demand at depot j in period t (kg/year)
N_j^t = number of shortage at depot j in period t (kg)
L_{kj}^t = lead time from plant k to depot j in period t (year)
B_j^t = shortage cost per kg at depot j in period t (IDR/kg)
b_j^t = shortage total cost at depot j in period t (IDR/year)
q_{kj}^t = ordering size from depot j to plant k in period t (kg)
r_j^t = inventory position at depot j at the end of ordering cycle in period t (kg)

3.1.1 Component Cost at Depot

Component cost at depot could be grouped into 4 sections were the total cost to operate depot j, throughput total cost at depot j, total holding cost at depot j, and shortage total cost at depot j. Operating cost at depot j during horizon planning was

$$\sum_{t=1}^{T}\sum_{j=1}^{W} o_j^t = \sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} A_{jk}^t \frac{1}{T_{kj}^t} \quad (1)$$

Ordering size: $q_{kj}^t = R_j^t - r_j^t$ (2)

Inventory maximum at depot j in period t was

$$R_j^t = (T_{kj}^t + L_{kj}^t)\, d_j^t + SS_j^t \quad (3)$$

Inventory position at the end of ordering cycle was

$$r_j^t = L_{kj}^t\, d_j^t + SS_j^t \quad (4)$$

Subtitution from (2), (3), and (4) so:

$$q_{kj}^t = T_{kj}^t\, d_j^t$$

Throughput total cost was

$$v_j^t = p_{jk}^t q_{kjx}^{rt}$$

$$\sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W}\sum_{i=1}^{C} v_j^t = \sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W}\sum_{i=1}^{C} p_{jk}^t (T_{kj}^t\, d_j^t)\, \frac{1}{T_{kj}^t}$$

$$\sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W}\sum_{i=1}^{C} v_j^t = \sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W}\sum_{i=1}^{C} p_{jk}^t\, d_j^t \qquad (5)$$

Inventory position at depot is shown in Figure 3.
Total holding cost at depot j in period t was

$$\sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} h_j^t = \sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} H_j^t (R_j^t - d_j^t L_{kj}^t + \frac{T_{kj}^t d_j^t}{2} + N_j^t) \qquad (6)$$

Shortage total cost at depot j in period t:

$$\sum_{t=1}^{T}\sum_{j=1}^{W} b_j^t = \sum_{t=1}^{T}\sum_{j=1}^{W} \frac{B_j^t\, N_j^t}{T_{kj}^t} \qquad (7)$$

3.1.2 Component Cost at Plant

Component cost at plant could be grouped into 3 section. They were total cost to operate plant k, total production cost at plant k, and total holding cost at plant k. Operating cost at plant k during one horizon planning (during period t or one year) was

$$\sum_{t=1}^{T}\sum_{k=1}^{M} g_k^t = \sum_{t=1}^{T}\sum_{k=1}^{P} (A_k^t\ \psi_k) + A_{pk}^t \qquad (8)$$

While: $\psi_k = \dfrac{\sum_{t=1}^{T}\sum_{j=1}^{W} d_j^t}{90\%}$

Total production cost was

$$v_k^t = p_k^t x_k^t$$

$$\sum_{t=1}^{T}\sum_{k=1}^{M} v_k^t = \sum_{t=1}^{T}\sum_{k=1}^{M} p_k^t\ x_k^t \qquad (9)$$

Maximum inventory at plant k was

$$R_{ok} = \sum_{t=1}^{T}\sum_{k=1}^{M} (d_k^t\ T_k^t\ (1 - \frac{d_k^t}{\psi_k})\ ) + \sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W} (d_j^t\ T_{kj}^t)\, y_{kj}^t +$$
$$\sum_{t=1}^{T}\sum_{j=1}^{W} (SS_j^t)\, y_{kj}^t \qquad (10)$$

Beginning inventory at plant k was

$$r_k^t = \sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W} (d_j^t\ T_{kj}^t)\, y_{kj}^t + \sum_{t=1}^{T}\sum_{j=1}^{W} (SS_j^t)\, y_{kj}^t +$$
$$\sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W} (d_j^t L_{kj}^t)\, y_{kj}^t \qquad (11)$$

From (10) and (11), so production size at the plant k was

$$x_k^t = R_{ok}^t - r_k^t$$

$$x_k^t = \sum_{t=1}^{T}\sum_{k=1}^{M} (d_k^t\ T_k^t\ (1 - \frac{d_k^t}{\psi_k})\ ) - \sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W} (d_j^t L_{kj}^t))\, y_{kj}^t$$

Inventory position at plant was shown in Figure 4.
Total holding cost at plant k in period t:

$$\sum_{t=1}^{T}\sum_{k=1}^{M} h_k^t = \sum_{t=1}^{T}\sum_{k=1}^{M} H_k^t (\frac{1}{2}(\sum_{t=1}^{T}\sum_{j=1}^{W} (d_j^t\ T_{kj}^t) +$$
$$\sum_{t=1}^{T}\sum_{k=1}^{M}\sum_{j=1}^{W} (d_j^t L_{kj}^t)\, y_{kj}^t +$$
$$T_k^t\ d_k^t\, (1 - \frac{d_k^t}{\psi_k}) + \sum_{t=1}^{T}\sum_{j=1}^{W} (SS_j^t)\ y_{kj}^t\ ) \qquad (12)$$

From (1), (5), (6), (7), (8), (9), and (12) we can find the total cost from depot and plant.

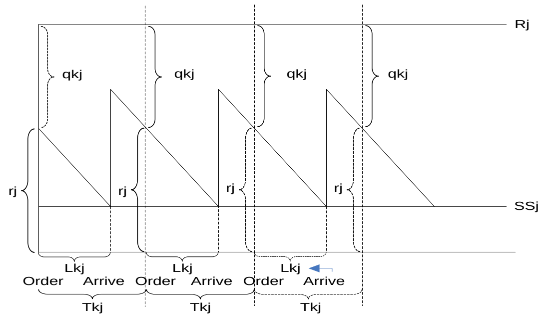

Figure 3: Inventory Position at Depot

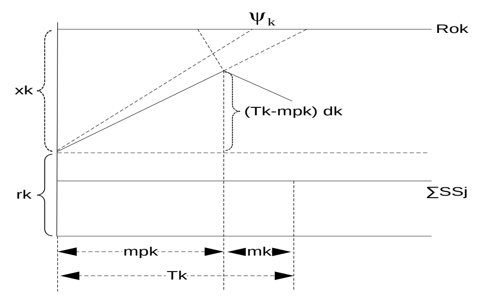

Figure 4: Inventory Position at Plant

3.1.3 Transportation Cost

Shipping cost at plant k in every ordering cycle plant k for shipping group β^t_{ke} consist of direct shipping cost and sharing shipping cost.

$$af^t_{ke} = apl^t_{ke} + apb^t_{ke} \quad (13)$$

Direct shipping cost was

$$apl^t_{ke} = \sum_{t=1}^{T}\sum_{j\in\beta_{ke}} \frac{1}{\varphi}\,(q^t_{kj})\,(C_f + C_d\ 2J_{kj}) \quad (14)$$

Sharing shipping cost was

$$apb^t_{ke} = \sum_{b} X_{bke}\left(\sum_{v\neq w\in\beta_{ke}} C_d\ 2J_{vw} + C_f\right) \quad (15)$$

3.2 Model Solution and Algorithm

The steps to reach the solution as follows:

1. Substitution limitation (1) with the total cost formula from depot and plant
2. Derive the above equation to $c\,T^t_{kj}$ to find T^t_{kj} optimal for certain value n^t_j, so:
$$\frac{\partial(TC_{dep} + TC_{plant})}{\partial T^t_{kj}} = 0$$
$$T^{t\;2}_{kj} = \frac{2\left(\sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} A^t_{jk} + \sum_{t=1}^{T}\sum_{j=1}^{W} B^t_j N^t_j\right)}{\sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} H^t_j(d^t_j)) + \sum_{t=1}^{T}\sum_{k=1}^{M} H^t_k + n^t_j\ d^t_k\left(1-\frac{d^t_k}{\psi_k}\right)} \quad (16)$$
3. Because T^t_k as same as length of horizon planning (T) so multiple value of ordering cycle was:
$$n^t_j = \frac{T}{T^t_{kj}} \quad (17)$$
4. R^t_j optimal obtainable with derive total cost formula from depot and plant to R^t_j
$$\frac{\partial(TC_{dep} + TC_{plant})}{\partial R^t_j} = 0$$
$$\alpha = \int_{r^t_{jjx}}^{\infty} (f(y_j)\,dy_j = \sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M} \frac{T^t_{kj}\,(H^t_j + H^t_k)}{T^t_{kj}\,H^t_j + T^t_{kj}\,H^t_k + B^t_j}\ y^t_{kj} \quad (18)$$

Before enter the stage of final solution, first necessary to determine the length of horizon planning where the length of the planning horizon will be the same as the length of the production cycle at plant. In research on determining the number and location of the new wheat flour plant there were 5 candidates for the location of the plant site and one was certain plant so that there would be a number of $\sum_{x=1}^{6} {}_6C_x$ solution. Of each solution generated will be known candidate plant which will be opened by inserting a binary decision variable (1 or 0).

In the calculation of all elements of the plant k cost serviced depot j also uses a binary decision variable (1 or 0), where if depot j serviced by plant k, it would be given 1 binary variable, whereas if it was not serviced by plant k it would be given a value of 0. The next step was the input parameters required for the calculation and determination of the initial solution by following these steps:

1. Initial solution
   For calculating T^t_{kj}, n^t_j, and R^t_j found by iterative using sthe Hadley Within following way:
   a. Calculate the length of ordering cycle from depot j to plant k with formulation:
   $$T^t_{kj} = \sqrt{\frac{2A^t_{jk}}{d^t_j\,H^t_j}}$$
   b. Calculate α with equation (18)
   c. Calculate the number of multiple cycle at depot j with equation (17)
   d. Calculate the number of maximum inventory at depot j with formulation:
   $$R^t_j = \sum_{t=1}^{T}\sum_{j=1}^{W}\sum_{k=1}^{M}\left(d^t_j\,T^t_{kj} + d^t_j\,L^t_{kj} + z_\alpha\,S^t_j\sqrt{T^t_{kj} + L^t_{kj}}\right)$$
   e. Calculate the number of shortage at each depot with formulation:
   $$N^t_j = S^t_j\sqrt{T^t_{kj} + L^t_{kj}}\,[f(z_\alpha) - z_\alpha\,\psi(z_\alpha)]$$
   f. Calculate total cost depot with equation

   The above solution was a solution to get the initial T^t_{kj} value, so that the required iterations to find a solution that can provide a total minimum cost.
2. Iteration reduction in T^t_{kj} value
   a. Do a reduction in the value iteration as one unit, then back to the first phase of step b up to f
   b. If the new results of depot total cost were smaller than early, followed by repeating the reduction iteration step 2 point a
   c. If the new results of depot total cost was larger than

early, stop and try to increase T_{kj}^{t} until find the optimal value that give minimum depot total cost.

3. Iteration increase in T_{kj}^{t} value
   a. Do increase in the value iteration as one unit, then back to the first phase of step b up to f
   b. If the new results of depot total cost was smaller than early, followed by repeating the reduction iteration step 3 point a
   c. If the new results of depot total cost was larger than early, stop and find depot total cost.
4. Calculate plant total cost
5. Calculate transportation total cost
6. Calculate total cost

The above steps were repeated until all possible solutions had been generated based on the number of combinations. Determination of the number and location of the plant based on the minimum total cost of the supply chain of all the possible solutions are generated.

4. DISCUSSION

Model tested using Delphi 2007 software to calculate the total cost of the supply chain. It was one plant location, 5 candidate plant locations, and 12 certain depot location, there were 31 alternatives solutions to determine the optimal location of the new wheat flour plant. From the test results model, total time for iteration was 8 seconds for a total of 31 alternatives and demand to 2025, the results showed the alternative that gave the smallest total cost of the supply chain was 3 plant located in South Sulawesi, Maluku Province, and Province of Papua.

Depot output given by the model for demand conditions in 2025 was shown in Table 1. Results depot output was the result of iterations that provide depot total cost of the smallest (optimal) for each depot location. The output of the plant was given by the model for demand conditions in 2025 was shown in Table 2. Locations plant in Maluku Province would meet the demand of 3 depots, South Sulawesi Province would meet the demand of 8 depots, and only meets the demand of Papua Province depot in his own province.

The output for the cost of transportation was provided by the model for demand conditions in 2025, all the requests from each depot filled with plant direct shipping and no sharing shipping.

Model validation was done by comparing the development of the model with the current system conditions. In the present conditions, there was only one wheat flour plant in Eastern Indonesia with a production capacity of 750,000 tons per year. The plant would meet the demand of wheat flour at Eastern Indonesia and if there were shortage, it would be met from Western Indonesia.

Sensitivity analysis was the analysis used to determine changes in the parameters and effects of changes in the coefficients of the continuous decision variables of the objective function after obtained optimal solution. Sensitivity analysis for the model developed in this study carried out on ordering cost and holding cost parameter with the increase and decrease respectively 10% of the initial conditions. Based on the calculation of the total cost of the supply chain with ordering cost and holding cost parameter change, it turned to increase and decrease costs by 10% provide significant solution changes in the number and location of the new wheat flour plant.

5. CONCLUSION

Based on the results of the model testing and discussion it could be given some conclusions:

a. The model developed was a model for determining the number and location of the new wheat flour plant and solved by using Delphi 2007 software, the model successfully determine the location of a new wheat flour plant in Eastern Indonesia.
b. The development model found the minimum supply chain total cost, where the supply chain total cost was calculated by the sum of the depot total cost, the plant total cost, and the transportation total cost.
c. There was one plant with certain location, 5 candidate plant locations, and 12 depot locations and would meet the demand for wheat flour at Eastern Indonesia until 2025 to build two new wheat flour plants at Maluku Province with a production rate of 106,000 tonnes/year and Papua Province with production rate of 64,000 tons/year in addition to existing plant that was in the province of South Sulawesi with the production rate of 750,000 tonnes/year.
d. The supply chain total cost resulting in the establishment of two new plants in the Maluku Province and Papua Province in addition to existing plant in the South Sulawesi Province was 8,088,855,266,523.43 IDR/year, which includes the depot total cost 4,635,747,144,720.79 IDR/year (57.3%), the plant total cost of 3,437,069,277,869.06 IDR/year (42.5%), and transportation total cost of 16,038,843,933.58 IDR/year (0.2%).
e. Model was valid because it gave better results in the supply chain total cost generated by the difference compared to the current condition in which there was only one wheat flour plant in South Sulawesi with production rate reached only 750,000 tons/year. The difference between the supply chain total costs with the existing condition that the solution given by the model reach 4,045,269,392.00 IDR

Table 1: Depot Total Cost

Prov.	Tk (year)	nj	Tkj (year)	R (kg)	N (kg/year)	Operating Cost (IDR/year)	Througput Cost (Rp/tahun)	Holding Cost (IDR/year)	Shortage Cost (IDR/year)	Total Cost (IDR/year)
West Nusa Tenggara	1	16	0.06114	12,616,605.64	3,959.13	134,117,437.98	690,947,919,890.00	928,289,996.95	1,061,977,987.69	693,072,305,312.62
East Nusa Tenggara	1	23	0.0426	9,550,348.29	2,255.01	255,585,207.15	904,483,670,008.71	1,298,052,494.07	1,152,696,565.07	907,190,004,275.00
North Sulawesi	1	11	0.08726	7,978,351.65	2,360.54	77,445,668.97	285,779,184,658.63	326,196,910.26	365,627,499.72	286,548,454,737.58
Central Sulawesi	1	14	0.07195	7,735,542.09	2,371.04	105,604,109.53	354,247,072,887.01	467,143,596.47	500,783,669.57	355,320,604,262.59
South Sulawesi	1	21	0.04677	17,637,154.12	4,138.91	154,467,117.47	1,084,549,031,287.94	930,684,010.67	1,278,651,500.79	1,086,912,833,916.87
South East Sulawesi	1	13	0.07887	6,763,894.58	2,031.74	96,904,870.71	292,551,939,431.11	419,414,616.97	393,770,413.73	293,462,029,332.51
Gorontalo	1	9	0.10709	3,789,149.38	1,453.45	69,009,576.67	129,697,295,641.88	217,804,742.46	200,604,132.29	130,184,714,093.30
West Sulawesi	1	9	0.11242	4,235,068.21	1,614.88	60,953,946.67	132,102,529,665.98	189,629,641.62	196,866,252.18	132,549,979,506.45
Maluku	1	12	0.08277	4,393,061.94	1,336.09	96,658,535.96	202,692,828,720.00	321,130,947.00	258,289,027.53	203,368,907,230.49
North Maluku	1	11	0.08974	3,174,899.08	933.25	89,144,114.58	131,995,588,160.00	225,720,655.43	166,388,268.89	132,476,841,198.90
Papua	1	15	0.06806	5,043,125.37	1,575.01	126,966,195.25	286,585,013,562.87	444,476,792.18	399,946,769.24	287,556,403,319.54
North Papua	1	11	0.08888	2,526,390.19	749.72	105,392,560.54	126,574,853,360.75	265,792,540.71	158,029,072.95	127,104,067,534.95

Tabel 2: Plant Total Cost

Plant Location	Maluku Prov.	South Sulawesi Prov.	Papua Prov.
Prouction Rate (kg/year)	106,000,000	750,000,000	64,000,000
Rok (kg)	60,209,976.12	163,894,967.71	36,374,173.56
SS (kg)	5,188,239.22	38,948,836.81	2,785,948.56
Operating Cost (IDR/year)	235,070,900.00	1,688,236,000.00	141,929,600.00
Production Size (kg/year)	55,221,456.94	479,918,844.74	33,164,149.55
Production Cost (IDR/year)	331,328,741,635.56	2,879,513,068,457.75	198,984,897,300.00
Holding Size (kg/year)	57,948,064.22	150,519,125.08	35,245,585.15
Holding Cost (IDR/year)	5,273,273,844.30	13,697,240,382.41	3,207,348,249.03
Total Cost (IDR/year)	338,290,251,479.87	2,894,898,544,840.16	203,880,481,549.03

f. Based on the result of the sensitivity analysis, the parameter changed by 10% the ordering cost and holding cost parameter up and down turned out to provide a change solutions in determining the number and location of the new wheat flour plant, thus it could be said that the model was sensitive to ordering cost and holding cost parameter.

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The APIEMS 2014 organizing committee is here to certify that the following personnel has been present at the 15th Asia Pacific Industrial Engineering and Management Systems Conference (APIEMS 2014) which was held at Ramada Plaza Jeju Hotel, Jeju, Korea from 12th to 15th of October 2014.

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We highly appreciate your contribution to the APIEMS 2014.

Sincerely yours,

Chi h. Jun

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