ISBN : 978-602-50913-0-8

The 18th APIEMS

Proceedings

The 18th Asia Pacific Industrial Engineering and Management System Conference (APIEMS2017)

3 - 6 December 2017
Hyatt Regency
Yogyakarta, Indonesia

organized by :

Industrial Engineering Study Program
Faculty of Industrial Technology
Bandung Institute of Technology

co-organizer :

The Indonesian Association of Industrial Engineering Higher Education Institution

Universitas Atma Jaya, Yogyakarta

Sepuluh Nopember Institute of Technology, Surabaya

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18th APIEMS 2017

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MESSAGE FROM THE APIEMS PRESIDENT

On behalf of the Asia Pacific Industrial Engineering and Management Society, I would like to welcome the participants to APIEMS 2017 Conference. Started in 1998, APIEMS has grown to become a major conference for industrial engineering and management systems in the Asia Pacific region with participants from all over the world.

I would like to thank to Conference Chair, Prof. Andi Cakravastia from Bandung Institute of Technology, as well as Conference Co-Chairs, Prof. Abdul Hakim Halim from Bandung Institute of Technology and Prof. Nyoman Pujawan from Institut Teknologi Sepuluh Nopember, Indonesia, who have made this conference a successful one.

I wish you have fruitful discussions at the conference and enjoy your stay at this beautiful ancient city of Yogyakarta.

Chi-Hyuck Jun
President, APIEMS
Professor, Industrial & Management Engineering
POSTECH, S. Korea

MESSAGE FROM RECTOR OF BANDUNG INSTITUTE OF TECHNOLOGY

It is an honor for Bandung Intitute of Technology (ITB) in collaboration with Institut Teknologi Sepuluh Nopember-Surabaya, and Atma Jaya University-Yogyakarta to host the 18th APIEMS 2017 in Yogyakarta. The city that is very important to history of our country, Indonesia.

ITB is going to celebrate its 100 years of delivering engineering higher education in Indonesia. We thank APIEMS for holding this conference in Indonesia and being part of our important milestone.

ITB pioneered industrial engineering higher education in Indonesia almost half century ago. Today, there are more than 250 industrial engineering programs in our country. We hope that by holding APIEMS in Indonesia, it will accelerate further development and role of industrial engineering in Indonesia.

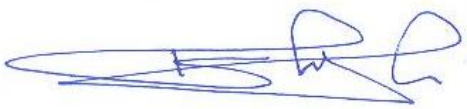
We sincerely express our gratitude to Ministry of Industry Republic of Indonesia, the Indonesian Association of Industrial Engineering Higher Education Institution, APIEMS, Keynote Speakers: Professor. D.N.P. (Pra) Murthy, Professor Emeritus of The University of Queensland, Professor Alexandre Dolgui, The Editor-in-Chief of the International Journal of Production Research, and all participants of the 18th APIEMS 2017 for their great support that make this conference possible.

Today, we are witnessing another revolution of industrial development. The internet of things era has lead the change on consumer behavior, innovate production system technology, and transform global supply chain. All of these may reshape our future.

On behalf of Bandung Institute of Technology, I encourage all participants of the 18th APIEMS 2017 to work together and contribute into future development of Industrial Engineering and Management System in Asia Pacific Region and create our better society.

We wish all participants to have a fruitful conference, expand our academic network, and enjoy the historical & cultural city of Yogyakarta.

Bandung, December 2017



Prof. Dr. Ir. Kadarsah Suryadi, DEA.
Rector of Bandung Institute of Technology

MESSAGE FROM THE GENERAL CHAIR

Welcome to the 18th APIEMS 2017 in Yogyakarta – Indonesia, an enchanted cultural city in Indonesia. It is our great privilege, Bandung Institute of Technology (ITB) collaborate with Institut Teknologi Sepuluh Nopember-Surabaya, and Atma Jaya University-Yogyakarta, to organize APIEMS in Indonesia.

By hosting the 18th APIEMS 2017 in Indonesia, we hope to contribute to the development of research and academic collaborative activities throughout Asia Pacific network in the field of Industrial Engineering and Management Systems. From the perspective of our country, we are very keen to promote development of Industrial Engineering and Management in Indonesia. We would like to continue the longstanding history of APIEMS as an important forum for exchanging ideas and information about latest development in industrial engineering and management system among professionals from Asia-Pacific countries.

The organizing committee would like to express our deep appreciation to Ministry of Industry Republic of Indonesia, Keynote Speakers: Professor. D.N.P. (Pra) Murthy, Professor Emeritus of The University of Queensland, Professor Alexandre Dolgui, The Editor-in-Chief of the International Journal of Production Research, APIEMS Fellows and Board Members, all of the Reviewers and Jury, all of the Contributors and Participants for their excellent contribution and support to the 18th APIEMS 2017. We thank to the Indonesian Association of Industrial Engineering Higher Education Institution, Bandung Institute of Technology, Institute Technology Sepuluh Nopember-Surabaya, and Atma Jaya University-Yogyakarta for the collaborative support to host the 18th APIEMS 2017.

We hope all participants of the 18th APIEMS 2017 to enjoy the conference and the cultural city of Yogyakarta.

Bandung, December 2017

Dr. Andi Cakravastia
Chair of 18th APIEMS 2017

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- Zahari Taha (Universiti Malaysia Pahang, Malaysia

Day 1: December 3 (Sunday)	
Registration Bogey's Teras Bogey's Teras, Hyatt Hotel 16:00 - 19:00	
	Welcome Party 17:00 - 19:00 Bogey's Teras, Hyatt Hotel
Day 2: December 4 (Monday)	
Registration Bogey's Teras Bogey's Teras, Hyatt Hotel 07:00 - 17:00	Fellow Meeting (Arjuna Room, Hyatt Hotel) 7:00 - 17:00
	Opening Ceremony (Ballroom) 9:00 - 10:00
	Coffee Break
	Keynote Speech : D.N.P. (Pra) Murthy; Alexandre Dolgui (Ballroom) 10:20 - 12:00
	Lunch (Kemangi Bistro, Hyatt Hotel) 12:00 - 13:20
	Parallel Sessions: 13:20 - 15:00
	Coffee Break
	Parallel Sessions: 15:20 - 16:40
	APIEMS Board Meeting (Bale Raos Meeting Room) 16:00 - 18:00
Board Dinner (Bale Raos Restaurant) 18:00 - 20:00	Dinner (Prambanan Temple) 18:00 - 20:00
Day 3: December 5 (Tuesday)	
Registration Bogey's Teras Bogey's Teras, Hyatt Hotel 07:00 - 17:00	Parallel Sessions: 8:20 - 10:00
	Coffee Break
	Parallel Sessions: 10:20 - 12:00
	Lunch (Kemangi Bistro, Hyatt Hotel) 12:00 - 13:20
	Parallel Sessions: 13:20 - 15:00
	Coffee Break
	Parallel Sessions: 15:20 - 17:20
	Banquet (Poolside, Hyatt Hotel) 18:00 - 20:00
Day 4: December 6 (Wednesday)	
Registration Bogey's Teras Bogey's Teras, Hyatt Hotel 07:00 - 10:00	Parallel Sessions: 8:20 - 10:00
	Coffee Break
	Parallel Sessions: 10:20 - 12:00
	Lunch (Kemangi Bistro, Hyatt Hotel) 12:00 - 13:20

Sunday, December 3 2017						
16:00 - 19:00	**Registration (Bogey's Teras, Hyatt Hotel)**					
17:00 - 19:00	**Welcome Party (Bogey's Teras, Hyatt Hotel)**					
Monday, December 4 2017						
7:00 - 17:00	**Registration (Bogey's Teras, Hyatt Hotel)**					
7.00 - 9:00	**Fellow Meeting (Arjuna Room, Hyatt Hotel)**					
9:00 - 10:00	**Opening Ceremony (Ballroom)**					
10:00 - 10:20	**Coffee Break 1 (Ballroom)**					
10:20 - 12:00	**Keynote Speech : D.N.P. (Pra) Murthy; Alexandre Dolgui (Ballroom)**					
12:00 - 13:20	**Lunch (Kemangi Bistro, Hyatt Hotel)**					
13:20 - 15:00	**Parallel Session 3**					
	A1	**B1**	**C1**	**D1**	**E1**	**F1**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	PPC 1	PPC 2	OR 1	Logistics & SCM 1	Logistics & SCM 2	Quality 1
Paper ID	289	52	161	278	239	48
	206	345	155	311	363	332
	140	284	89	110	62	362
	2	305	10	203	39	58
	88	274	165	212	187	57
15:00 - 15:20	**Coffee Break 2**					
15:20 - 16:50	**Parallel Session 4**					
	A2	**B2**	**C2**	**D2**	**E2**	**F2**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	OR & Optimization 1	OR & Optimization 2	OR & Optimization 3 & Product Design 1	Maintenance 1	Modelling 1	Sustainability 1
Paper ID	246	11	18	112	195	134
	306	172	38	91	7	267
	173	8	317	302	233	268
	136	323	127	35	204	132
16:00 - 18:00	**APIEMS Board Meeting (Bale Raos Meeting Room)**					
18:00 - 20:00	**Dinner (Prambanan Temple)**					
18:00 - 20:00	**Board Dinner (Bale Raos Restaurant**					
Tuesday, December 5 2017						
7:00 - 17:00	**Registration (Bogey's Teras, Hyatt Hotel)**					
8:20 - 10:00	**Parallel Session 1**					
	A3	**B3**	**C3**	**D3**	**E3**	**F3**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	Product Design 1	Logistics & SCM 3	Maintenance 2	Information System 1	Optimization 2	Eng Economy 1

Paper ID	198	245	235	51	26	138
	254	307	70	174	73	215
	263	63	276	163	210	93
	190	28	211	171	354	180
	357	179	104	196	145	9
	271	337	154	24	23	4
10:00 - 10:20	**Coffee Break 1**					
10:20 - 12:00	**Parallel Session 2**					
	A4	**B4**	**C4**	**D4**	**E4**	**F4**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	Logistics & SCM 4	Logistics & SCM 5	Logistics & SCM 6	Information System 2	Technology Mgmt 1	Eng Economy 2
Paper ID	234	17	86	66	60	160
	99	19	318	71	170	12
	153	217	209	141	199	122
	96	247	192	325	283	14
	188	107	72	42	269	353
12:00 - 13:20	**Lunch (Kemangi Bistro, Hyatt Hotel)**					
13:20 - 15:00	**Parallel Session 3**					
	A5	**B5**	**C5**	**D5**	**E5**	**F5**
	Bromo 1	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	Modelling 2	Optimization 1	Quality 3	Information System 3	Logistics, SCM & Service System	Ergonomics 1
Paper ID	205	6	77	164	84	279
	207	285	300	124	83	162
	208	295	277	15	266	261
	175	280	97	227	111	75
	49	65	87	238	130	159
15:00 - 15:20	**Coffee Break 2**					
15:20 - 16:50	**Parallel Session 4**					
	A6	**B6**	**C6**	**D6**	**E6**	**F6**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	Maintenance 2 & Optimization 2	Quality 2	IE Education 1	IE Education 2	Ergonomics 2	Sustainability 2
Paper ID	34	30	202	270	40	355
	55	344	340	214	324	264
	223	27	114	129	333	32
	158	51	125	128	50	167
	150	350	230	94	44	46
	241	312	194	92	146	
18:00 - 20:00	**Banquet (Poolside, Hyatt Hotel)**					

Wednesday, December 6 2017						
7:00 - 10:00	**Registration (Bogey's Teras, Hyatt Hotel)**					
8:20 - 10:00	**Parallel Session 1**					
	A7	**B7**	**C7**	**D7**	**E7**	**F7**
Room	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Session name	Ergonomics 3	Ergonomics 4	Logistics & SCM 7	Service System 1	Service System 2	Eng Economy 1
Paper ID	85	81	296	281	351	105
	258	76	342	358	142	68
	320	126	329	334	298	67
	80	232	216	297	133	143
	189	31		90	213	256
	224	22		43	116	286
						113
10:00 - 10:20	**Coffee Break 1**					
10:20 - 12:00	**Parallel Session 2**					
	A8	**B8**	**C8**	**D8**	**E8**	**F8**
Session name	**Bromo 1**	**Bromo 2**	**Bromo 3**	**Merapi 1**	**Merapi 2**	**Merapi 3**
Paper ID	PPC 3	Ergonomics 5	Technology Mgmt 2	Other	Special Session 2	Others
	242	117	47	349	Special Paper 1	
	249	20	328	137	Special Paper 2	
	253	21	37	121	Special Paper 3	
	265			248	Special Paper 4	
	243			359	343	
12:00 - 13:20	Lunch (Kemangi Bistro, Hyatt Hotel)					

FLOOR PLAN : Hyatt Regency

1. Hyatt Regency Yogyakarta Entrance (Concierge & Golden Bird Area)
2. Lobby Court
3. Ballroom Corridor
4. Ballroom Restroom
5. Ballroom
6. Lobby Reception
7. Merbabu Room
8. Arjuna Room
9. Regency Lounge
10. Kemangi Bistro Restaurant
11. Merapi Garden
12. Bogey's Teras

An Inventory Decision Model of Two Products with Vector Autoregressive Demand

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Abstract. An inventory system that consist of two different products is considered in this paper. Demand of these products have purchase dependent power, i.e. demand of product A is affecting demand of product B, and vice versa. Then, a vector autoregressive VAR(1) model is being used as the reference forecasting model for the demand pattern. This forecasting model is being used as a basis for determining inventory policy for two products with purchase dependent power. An inventory decision model regarding when and how much to order of these products is developed in order to minimize total inventory cost consists of ordering and holding cost. Possibility to reducing order cost by joining replenishment of these products also being evaluated.

Keywords: purchase dependent power, vector autoregressive, inventory decision model, joint replenishment

1. INTRODUCTION

The purchase dependency is appeared in the retail industry. According to Bala (2008a), there are two types of purchase dependencies, within transaction and inter-transactional. Purchase dependency within transaction occurs in a single purchase transaction, while an inter-transactional purchase dependency occurs between a single purchase transaction and a previous purchase transaction. It is also studied that consumer behavior that leads to purchase dependency on products can be used as a decision-making tool and the preparation of marketing strategy, product, product arrangement on the display rack, and inventory arrangement of retail company's goods (Bala, 2008b). One possible way to determine the purchase dependency is using regression analysis (Bala, 2010).

Consideration of purchase dependence into inventory decision making has been studied by Park and Seo (2013). They developed the model purchase dependence with reference continuous review (Q, R) model and periodic review (R, T) model. They able to prove the importance of purchase dependence in determining inventory policy by showing the effect of purchase dependence on the total inventory cost, i.e. by considering purchase dependence while determining inventory policy can decrease inventory cost.

In different way, Ai, et al. (2016) developed forecasting model of purchase dependence demand by using the vector autoregressive VAR(1) model. They confirmed the model from a clothing retail company and conducted several experiments to study the nature of the developed VAR(1) model. It is shown that the VAR(1) equation in the purchase dependence product can be used for products with linear increasing and linear decreasing linear demand.

In this paper, we tried to develop a methodology for determining the inventory policy of two products when the demands are following the VAR(1) forecasting model.

2. METHODOLOGY DEVELOPMENT

Following Ai, et al. (2016), the vector autoregressive VAR(1) model can be mathematically formulated as follow

$$Y_{1,t} = \delta_1 + \phi_{1,1} Y_{1,t-1} + \phi_{1,2} Y_{2,t-1} + \varepsilon_{1,t} \quad (1)$$

$$Y_{2,t} = \delta_2 + \phi_{2,1} Y_{1,t-1} + \phi_{2,2} Y_{2,t-1} + \varepsilon_{2,t} \quad (2)$$

where

$Y_{i,t}$: demand of product *i* at period *t*

$\phi_{i,j}$: an autoregressive coefficient, which represents the effect of demand product i at period (t–1) on demand product j at period t

δ_i : an autoregressive coefficient, which represents the part of demand product i at period t that is not affected by past demand

$\varepsilon_{i,t}$: error term of autoregressive equation i, which represents the part of demand product i at period t that cannot explained by the autoregressive equation

From equations (1) and (2), it is known that the demand of product 1 and 2 over certain periods of time T can be forecasted with the knowledge of parameters $\phi_{i,j}$, δ_i, and initial value of demand $Y_{i,0}$. If the error terms of these forecast model is dropped, the demands can be considered as deterministic and dynamic. Therefore, in order to determine an inventory policy for the two products following equations (1) and (2), dynamic economic lot size model of Wagner and Whitin (1958) is selected as reference model.

Two alternatives of procedure are proposed here. The first alternative is independently applying the Wagner-Whitin model for each product for obtaining the inventory policy, i.e. the replenishment schedule for each product. The second alternative is modifying the Wagner-Whitin model so that the replenishment schedule for all products are the same.

For the first alternative, the basic total cost equations for determining the inventory policy is as follow:

$$TC = \min \begin{cases} s_1 + h_2 Y_{i,2} + \cdots + h_t Y_{i,t} \\ a_1^* + s_2 + h_3 Y_{i,3} + \cdots + h_t Y_{i,t} \\ \vdots \\ a_{t-1}^* + s_t \end{cases} \quad (3)$$

where:

h_t : holding cost for period t

s_t : setup cost for period t

a_t^* : optimal cost at period t

While for the second alternative, the basic total cost equations for determining the inventory policy consists of the holding cost for all products, as follow:

$$TC = \min \begin{cases} s_1 + h_2 Y_{1,2} + h_2 Y_{2,2} + \cdots + h_t Y_{1,t} + h_t Y_{2,t} \\ a_1^* + s_2 + h_3 Y_{1,3} + h_3 Y_{2,3} \cdots + h_t Y_{1,t} + h_t Y_{2,t} \\ \vdots \\ a_{t-1}^* + s_t \end{cases} \quad (4)$$

3. NUMERICAL EXAMPLE

Let consider two products VAR(1) forecasting model with following equations:

$$Y_{1,t} = -10.715 + 0.553 Y_{1,t-1} + 1.328 Y_{2,t-1} \quad (5)$$

$$Y_{2,t} = 23.128 + 0.337 Y_{1,t-1} - 0.050 Y_{2,t-1} \quad (6)$$

Based on these equations, the demand of each product can be written as Table 1.

Table 1: Demand of products

Period	Product 1	Product 2
1	177	52
2	156	80
3	182	72
4	185	81
5	199	81
6	208	86
7	219	89
8	228	93
9	238	95
10	248	98
11	257	102
12	266	105

For simplest test case, it is assumed that the unit holding cost for all product and all period is equal to 1. Various setup cost and holding cost ratio are considered, which are 1:100 up to 1:1000. Implementing the alternatives for obtaining the replenishment schedule, it is obtained that the replenishment schedule for product 1 and 2 for the first alternative solution are shown in Table 2 and 3, respectively. While the replenishment schedule for both product 1 and 2 for the second alternative solution is shown in Table 4.

The comparison of total cost between the first and second alternatives are presented in Figure 1. It is noted that total cost of the second alternative (blue lines) is smaller than the total cost of the first alternative (orange lines) across the setup to holding cost ratio.

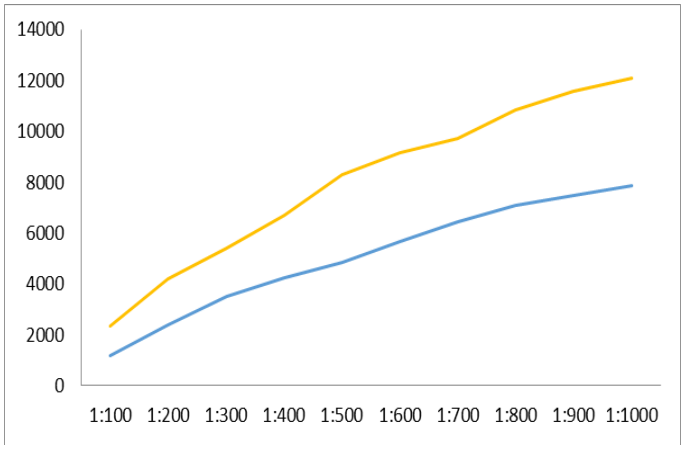

Figure 1: Comparison of Total Cost

Table 2: Replenishment schedule for product 1 for the first alternative

Period / Ratio	1	2	3	4	5	6	7	8	9	10	11	12	No. Replenishment
1:100	x	x	x	x	x	x	x	x	x	x	x	x	12
1:200	x		x		x	x	x	x	x	x	x	x	10
1:300	x		x		x		x		x		x		6
1:400	x			x		x		x		x	x		6
1:500	x			x			x			x		x	5
1:600	x				x			x			x		4
1:700	x				x			x			x		4
1:800	x					x				x			3
1:900	x					x				x			3
1:1000	x					x				x			3

Table 3: Replenishment schedule for product 2 for the first alternative

Period / Ratio	1	2	3	4	5	6	7	8	9	10	11	12	No. Replenishment
1:100	x		x		x		x		x	x	x	x	8
1:200	x			x			x			x		x	5
1:300	x				x			x			x		4
1:400	x					x				x			3
1:500	x						x					x	3
1:600	x						x					x	3
1:700	x							x					2
1:800	x							x					2
1:900	x								x				2
1:1000	x								x				2

Table 4: Replenishment schedule for both products 1 and 2 for the second alternative

Period / Ratio	1	2	3	4	5	6	7	8	9	10	11	12	No. Replenishment
1:100	x	x	x	x	x	x	x	x	x	x	x	x	12
1:200	x	x	x	x	x	x	x	x	x	x	x	x	12
1:300	x		x		x		x	x	x	x	x	x	9
1:400	x		x		x		x		x		x		6
1:500	x		x		x		x		x		x		6
1:600	x			x			x		x		x		5
1:700	x			x			x			x		x	5
1:800	x				x			x			x		4
1:900	x				x			x			x		4
1:1000	x				x			x			x		4

4. CONCLUDING REMARKS

This paper demonstrates that Wagner-Whitin algorithm and its modification can be applied for determining the inventory policy, i.e. the replenishment schedule for two products that has purchase dependence property and being forecasted using VAR(1) model. The numerical examples show that the second alternative, which make the replenishment schedule for all products are the same, provides smaller total cost than the first one.

It is important that error term is being considered in the future research. Furthermore, the study should compare in detail the effect on considering or not the purchase dependence property in the inventory model, i.e. to prove whether the total inventory cost is reduced when purchase dependence is being considered

ACKNOWLEDGMENT

This work is partially supported by Ministry of Research, Technology, and Higher Education, Republic Indonesia under International Research Collaboration and Scientific Publication Research Grant No. 045/HB-LIT/IV/2017.

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