Inventory Policy for Dependent Demand Where Parent Demand Has Decreasing Pattern

Y.N.A. Pratama, M. Darmawan, R.D. Astanti*, T.J. Ai, and D.C. Gong

ABSTRACT

When a product reaches its maturity in its life cycle, some innovations have to be put in that product in order to lengthen its life cycle. Otherwise, that product will be perceived as obsolete. It might affect the demand of that product i.e. the demand become decreasing. Based on the observation that we conducted over two smart phone brands, the phenomena that the demand has declining pattern really happened in the real situation. In addition, the observation shows that the product life cycle is getting shorter. This implies that the manufacturer has to deal with decreasing demand more often. A case study is presented in this paper, in which manufacturer experienced final product with decreasing demand pattern. Some lot sizing techniques, such as Lot for Lot, Silver Meal 1, Silver Meal 2, Least Unit Cost, Part Period Balancing, and Incremental, are tested to solve the inventory policy for both final product (parent) and its components (child). It is concluded that a company should not consider only one component or one level whenever deciding the inventory policy, i.e. production lot size. It is shown by the case study that the best lot sizing technique for a particular parent of product whenever the company only consider the parent is different with the best lot sizing technique whenever the company consider the parent and its child. For the case presented, it is shown that the smallest total cost of parent and child is most likely occurred whenever Silver Meal 2 lot sizing technique is applied in the parent with decreasing demand pattern.

Keywords: Inventory policy, dependent demand, decreasing demand, product life cycle.

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1. INTRODUCTION

There exists a phenomenon telling that product life cycle is getting shorter, especially in the technologically dynamic product such as personal computer (Bayus, 1998). When the researchers discuss about product life cycle then it can be seen from the point of view of product life cycle at industry level, product category level, product technology level or product model level (Bayus, 1994). In addition, according to Bayus (1998) “product technology lifetimes generally are longer than product model lifetimes”.

Product life cycle shows a stage that has been passed by a product started from introduction stage when the product is initially launched (birth), growth stage, mature stage and decline stage (death) (Cox, 1967; Bayus, 1998; Golder and Tellis, 2004). According to Kurawarwala and Matsuo (1994), the life cycle of product especially in consumer electronic and personnel computer is getting shorter which was 1 – 2 years. Bayus (1998) studied 20 brand model life times for 20 personnel computer manufacturer and concluded that the mean product life cycle length for those brands are3.68 years.

The impact of this phenomenon to the manufacturing side had been studied by some researchers such as Bayus (1998) stated that the shrinkage of product life cycle has implications in technology management and product planning. The effect of product life cycle to product strategy in an Original Equipment Manufacturer (OEM) of mobile phone had been studied also by Giaccheti and Marchi (2010). Other researchers studied the impact of

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product life cycle to the production and procurement decision including the inventory policy in a company (Kurawarwala and Matsuo (1994).

It is noted that, since the life cycle of product is finite, then, inventory policy considering product life cycle is basically developed for a finite planning horizon. Moreover, according to Diponegoro and Sarker (2002), finite planning horizon is more appropriate than infinite planning horizon, especially when dealing with the products which have short life cycle. Inventory policy for increasing demand pattern that is the growth stage in the product life cycle had been conducted by many researchers such as Reshet al. (1976), Donaldson (1977), Henery (1979), Hariga (1993), Lo et al. (2002), Silver (1979), Ritchie (1980), Kicks and Donaldson (1980), Goyalet al. (1986), Phelps (1980), Mitraet al. (1984), Ritchie (1984), Dave (1989b), Amrani and Rand (1990), Teng (1994), Barbosa and Friedman (1978), Friedman (1981), Yang et al. (1999), Wang (2002), Tenget al. (1997), Goyal and Giri (2000), Deb and Chaudhuri (1987), Dave (1989a), Goyalet al. (1996), Murdheswar (1988), Hariga (1994), Hariga and Goyal (1995), Teng (1996), Deb and Chauduri (1987), Montgomery et al. (1973), San Jose et al. (2005), San Jose et al. (2006), Zhou et al. (2004), Hariga (1994), Yang (2006).

Beside for increasing demand, several researchers conducted the research related to decreasing demand pattern that is in the declining stage of the product life cycle. However, the number of researcher that conduct the research on inventory policy considering decreasing demand pattern is not as many as that of considering increasing demand pattern such as Wee (1995), Benkherouft (1995), Yang et al.(2004), Goyal and Giri (2003), Zhao et al. (2001), Hill et al. (1999).

It is noted that those researches above were conducted dealing with independent demand. And usually the demand is based on hypothetical data. However, in reality there exists situation when the demand of certain item is affected by the demand of other item or it is called as dependent demand. For example in the personal computer (PC) manufacturer, the demand of mother board is affected by the demand of PC as mother board is one of the components of PC.

To the best of author knowledge, the inventory policy dealing with dependent demand had been conducted by Pujawan and Kingsman (2003), where the demand pattern is lumpy. In addition, the data is hypothetical. The research in this paper has contribution in exploring lot sizing for decreasing demand using real data in an electronic manufacturer. To give the reader have more insight on the decreasing demand pattern, the product life cycle for two smartphone brands which are Samsung and Blackberry using the retail data from 2011-2013 in a phone shop are provided. Then an inventory policy for an electronic product where its parents demand follows decreasing pattern is studied.

2. PRODUCT LIFE CYCLE OF TWO SMARTPHONE BRANDS

This section is presented in order to give a more insight about the decreasing demand pattern by providing a real data of the sales of two smartphone brands which are Samsung and Blackberry in a phone shop namely “X”. For this research, the retailer allowed us to retrieve sales data from April 2011 to March 2013.

To identify product life cycle of each product model of Samsung brand and Blackberry brand, several steps were performed as follows:

1) Grouping each product model of Samsung brand and Blackberry brand according its family product.

Smartphone Samsung brand sold in this retailer can be classified in to 4 families. They are: a) Samsung Galaxy S (S, S2, S3, S3 Mini); b) Samsung Galaxy Young (Young S5360; Young Duos S6102; Young S6310) ; c) Samsung Galaxy Note (Note, Note 2); d) Samsung Galaxy Mini (Mini, Mini 2). Smartphone Blackberry brand sold in this retailer can be classified in to 4 families. They are: a) Family A (9700, 9780, 9790); b) Family B (9000, 9900); c) Family C (8520, 9300, 9220, 9320); d) Family D (9520, 9860, 9380, Z10).

2) Observing sales data.

Sales data used to analyze product life cycle in this research is the sales data from April 2011 to March 2013. This due to the reason that the owner of phone shop “X” allowed us to retrieve the sales data for that period only. Sales data of both Samsung brand and Blackberry brand are presented in Table 1 and Table 2. Beside information about sales data, Table 1 and 2 provides information about:

a) The time when a certain model of Samsung and Blackberry smartphone launched in the market (showed in yellow colour);
b) The information of the stage of the smartphone in the product life cycle i.e., introduction, mature, decline or end-of-life (EOL). In this research the terminology end-of-life is used to represent the condition when there is no demand on a particular product model.
c) cycle life which means the elapsed time from when the product model is firstly launched in to the market until reach its end-of-life.

Table 1. Sales Data of Samsung

	Galaxy S2	Google Nexus S	Galaxy Mini	Galaxy S2	Galaxy Young S5360	Galaxy Note	Galaxy Young S5360	Galaxy Ace Plus	Galaxy Mini 2	Galaxy Tab27,0 P3100	Galaxy S Advance	Galaxy Ace 2	Galaxy S3	Galaxy Ace Duos	Galaxy Note 2	Galaxy Pocke Duos	Galaxy S3 mini	Galaxy Young S6310
Mar-10																		
Nov-10		2																
Dec-10		1																
Jan-11		1																
Feb-11		1	5															
Mar-11		0	6															
Apr-11	2	1	4	0														
May-11	1	0	4	2														
Jun-11	1	1	5	2														
Jul-11	0	0	4	3														
Aug-11	0	0	4	3														
Sep-11	0	0	5	3														
Oct-11	0	0	5	3	11	2												
Nov-11	0	0	4	3	15	6												
Dec-11	0	0	6	4	13	7												
Jan-12	0	0	6	4	12	6												
Feb-12	0	0	1	5	14	6	7	2										
Mar-12	0	0	0	5	14	7	9	3	2									
Apr-12	0	0	0	5	13	6	10	4	3	3	1							
May-12	0	0	0	2	14	6	9	5	3	5	3	4	1					
Jun-12	0	0	0	1	15	7	9	6	4	4	6	3	2	2				
Jul-12	0	0	0	0	13	6	9	4	6	8	4	6	3	4				
Aug-12	0	0	0	0	15	6	9	4	7	8	4	5	4	5				
Sep-12	0	0	0	0	13	6	8	6	9	8	5	6	4	5	3	4		
Oct-12	0	0	0	0	12	3	8	5	11	8	4	6	5	6	4	4		
Nov-12	0	0	0	0	10	1	8	5	11	7	5	5	5	6	3	7	1	
Dec-12	0	0	0	0	9	0	8	5	11	8	5	5	5	6	4	6	3	
Jan-13	0	0	0	0	9	0	6	4	11	8	4	5	5	5	5	6	4	
Feb-13	0	0	0	0	9	0	5	2	9	7	3	5	4	6	5	5	4	
Mar-13	0	0	0	0	8	0	3	1	6	5	3	2	3	4	4	2	5	10
product launch	Mar-10	Nov-10	Feb-11	Apr-11	Okt-11	Okt-11	Feb-12	Feb-12	Mar-12	Apr-12	Apr-12	Mei-12	Mei-12	Jun-12	Sep-12	Sep-12	Nov-12	Mar-13
status (Mar-13)	EOL	EOL	EOL	EOL	decline	EOL	decline	decline	decline	decline	decline	decline	decline	mature	mature	decline	increasing	introduction
cycle length	16	8	13	15	>18	14	>14	>14	13	12	12	11	11	10	7	7	5	1

Table 2. Sales Data of Blackberry

	9000	8900	8520	9700	9550	9105	9300	9800	9780	9810	9900	9360	9860	9790	9380	9220	9320	Z10
Nov-08																		
Agu-09																		
Nov-09																		
Apr-10																		
Agu-10																		
Nov-10																		
Apr-11	2	2	19	3		2	6	6	6									
May-11	1	1	16	3		2	7	7	6									
Jun-11	2	0	18	3		1	6	7	5									
Jul-11	1	0	14	2		2	5	6	5									
Aug-11	2	0	15	3		0	7	5	5	2	2	0						
Sep-11	1	1	20	2	1	2	6	5	5	2	2	1	0					
Oct-11	1	1	17	3	1	2	7	4	4	3	3	1	0					
Nov-11	2	0	15	2	0	2	6	4	4	3	5	1	1					
Dec-11	2	0	16	3	0	1	7	5	3	3	5	2	1	3	0			
Jan-12	1	1	17	2	0	2	6	4	4	3	7	1	2	4	1			
Feb-12	1	1	14	3	0	2	6	5	4	3	7	2	3	5	1			
Mar-12	2	0	15	3	0	2	8	3	3	4	5	1	3	5	3			
Apr-12	2	1	14	3	1	3	5	3	4	4	8	2	3	6	2			
May-12	1	1	18	3	0	2	5	5	3	4	5	1	3	6	4	3	0	
Jun-12	1	1	11	3	0	2	4	5	4	4	5	1	3	6	3	3	2	
Jul-12	1	1	16	2	0	2	4	4	3	4	7	3	3	7	3	4	3	
Aug-12	0	1	22	3	0	3	2	4	3	4	8	3	3	7	3	5	5	
Sep-12	1	0	9	3	0	2	1	4	3	3	5	1	3	7	3	5	5	
Oct-12	0	0	6	2	0	2	1	3	3	2	1	1	2	7	2	4	6	
Nov-12	0	0	3	1	0	2	1	2	1	1	1	1	1	7	2	5	6	
Dec-12	0	0	2	0	0	2	1	2	0	1	2	0	1	7	1	7	7	
Jan-13	0	0	1	0	0	1	1	2	0	0	2	0	1	7	1	8	8	0
Feb-13	0	0	0	0	0	0	2	1	1	0	3	0	1	6	0	5	4	0
Mar-13	0	0	0	0	0	0	0	0	0	0	1	0	1	4	0	5	3	0
product launch	Mei-08	Nov-08	Agu-09	Nov-09	Nov-09	Apr-10	Agu-10	Agu-10	Nov-10	Agu-11	Agu-11	Agu-11	Sep-11	Des-11	Des-11	Mei-12	Mei-12	Jan-13
status (Mar-13)	EOL	EOL	EOL	EOL	EOL	EOL	EOL	EOL	EOL	EOL	decline	EOL	decline	decline	EOL	decline	decline	introduction
cycle length	53	46	42	37	30	34	31	31	28	17	>20	16	>19	>16	14	>11	>11	>3

3) Plotting sales data of each family product of Samsung brand and Blackberry brand as it is shown in Figure 1 – Figure 8.

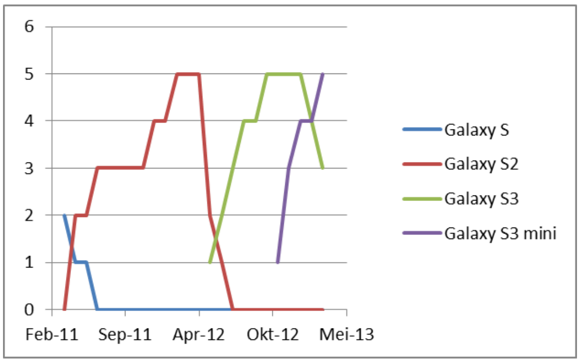

Figure 1. Product life cycle of Samsung Galaxy S Model

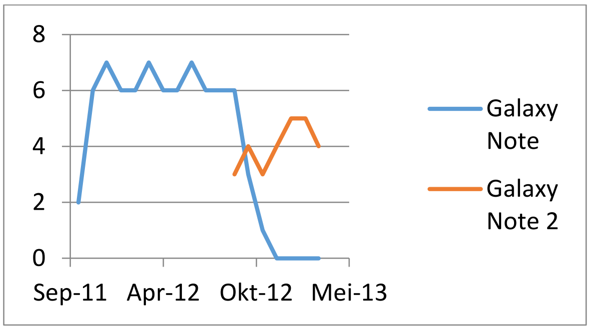

Figure 2. Product life cycle of Samsung Galaxy Note Model

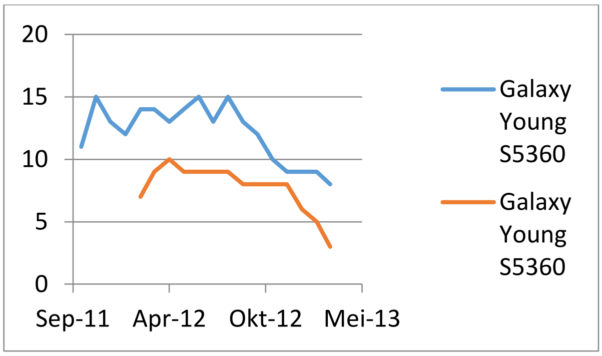

Figure 3. Product life cycle of Samsung Galaxy Young Model

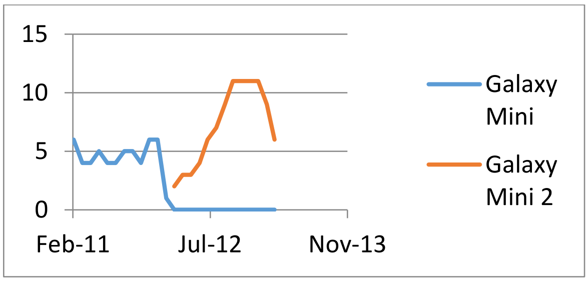

Figure 1. Product life cycle of Samsung Galaxy Mini Model

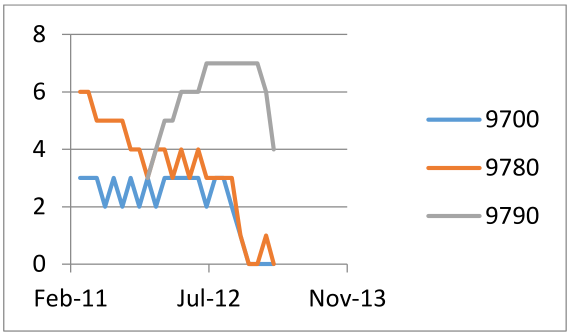

Figure 5. Product life cycle of Family A Blackberry

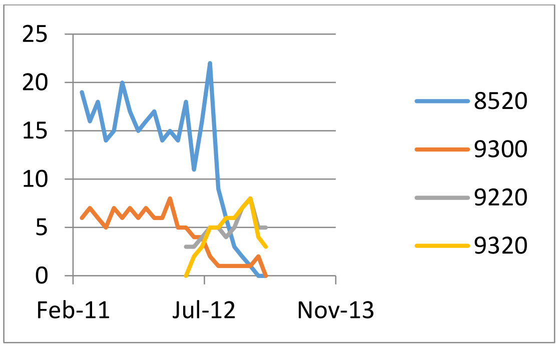

Figure 6. Product life cycle of Family B Blackberry

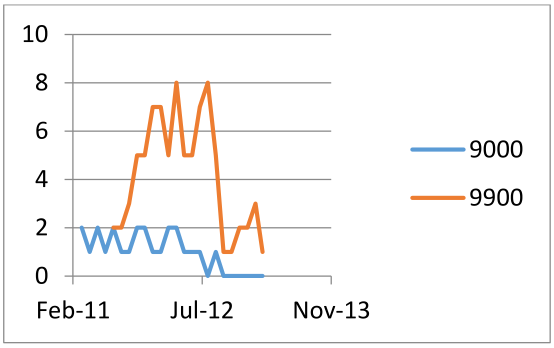

Figure 7. Product life cycle of Family C Blackberry

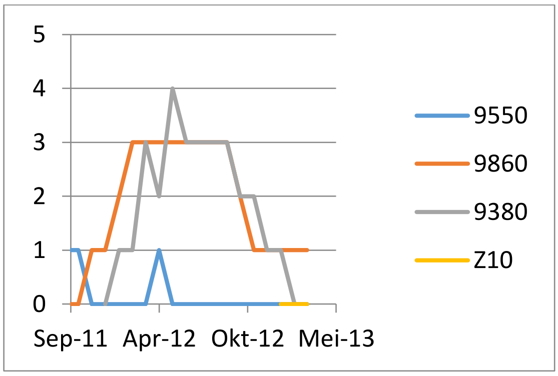

Figure 8. Product life cycle of Family D Blackberry

Based on Figure 1 and 4 above it can be seen that product life cycle curve of Samsung and Blackberry smartphone are following classical product life cycle pattern as it was provided by Cox (1967), follow introduction, growth, mature and decline. In addition it can be seen that when certain model is turning to declining phase, then a new model has been existed in the market in order to replace the previous one. Other aspect that it can be seen from Figure 1 – 8 is that the product life cycle length for each product model is also getting shorter. This phenomena is in line with what Bayus (1994) had stated which is *"the length of product life cycle is getting shorter over time*". In addition based on the observation that we conducted, the phenomena that the demand has declining pattern really happened in the real situation. In addition, the length of cycle is getting shorter. This implies that the manufacturer has to deal with decreasing demand more often.

3. A CASE STUDY ON INVENTORY POLICY FOR DEPENDENT DEMAND WHERE PARENTS DEMAND IS FOLLOWING DECREASING PATTERN

While in the previous section, the research conducted in this paper was trying to give a reader more understanding about the phenomena of decreasing pattern using two example of smart phone in a retailer, in this section we conducted the research to study how that situation affect the manufacturer in determining inventory policy. As the product life cycle is getting shorter, therefore a manufacturer faces the situation dealing with shorter length of cycle more often. Therefore, in the production planning and inventory planning area, a manufacturer has to consider about the phenomea of decreasing demand pattern. If the company does not consider this they may end up with huge quantity of leftover products that can not be absorbed in the market. For discrete product where the final product is made from its component or sub-component, if the company does not consider the decreasing demand pattern of the final product, then it may affect the inventory policy decision of its component and sub-component. This section provides a case study in an electronic manufacturer that is facing a decreasing demand in their final product. The problem found was related to determine the quantity order of one of the component. 6 lot sizing techniques available in the literature, which are Lot for Lot, Silver Meal 1, Silver Meal 2, Least Unit Cost, Part Period Balancing, and Incremental were applied to conclude which lot sizing technique appropriate for the decreasing demand pattern.

3.1. Case Study Description

This study was conducted in an electronic manufacturer. This company produces a single family of product which consists of 5 types of products. They are "1", "2," "3", "4", and "5". Each product is built from several components and sub-assemblies. In order to build that product, it requires 3 processes. The first process is purposed to build sub assembly AA. The second process is purposed to process sub assembly BB and the third process is purposed to assembly final product. The process to build sub assembly AA is the first operation to build the product. This subassembly consists of two parts which are N and U. The next operation is processing sub assembly BB. Sub assembly BB consists of several components and subassembly. They are AA, I, P, R, F, C and G. The last assembly process is assembling final product. To assembly the final product it requires sub assembly BB, M, T, D, V, K, R, A, O, L, W, w, Z, Y, X, D, and Q. The structure of Bill of material of Product "1" is presented in Figure 9.

The structure of Bill of Material of Product "2", "3", "4" and "5" are the same as that of product "1". However the components to build subassembly AA are different for each product. Therefore we use the notation AA_i to represent the sub assembly for building final product *i*¸ where *i* is the type of product "1", "2", "3", "4", and "5".

From Figure 9 below, it can be seen that the product produced by this manufacturer is discrete product where by disassembling it, component and sub assembles that form the final product can be identified easily. Recently, according to the information received from the company it is known that the demand of final product is decreasing. According to the data collected during the period of 130 weeks (divided into quarters where one quarter consist of 13 weeks), demand of sub-assemblies AA_1, AA_2, AA_3, AA_4, AA_5 that support 5 types of product produced in this company can be shown in Figure 10.

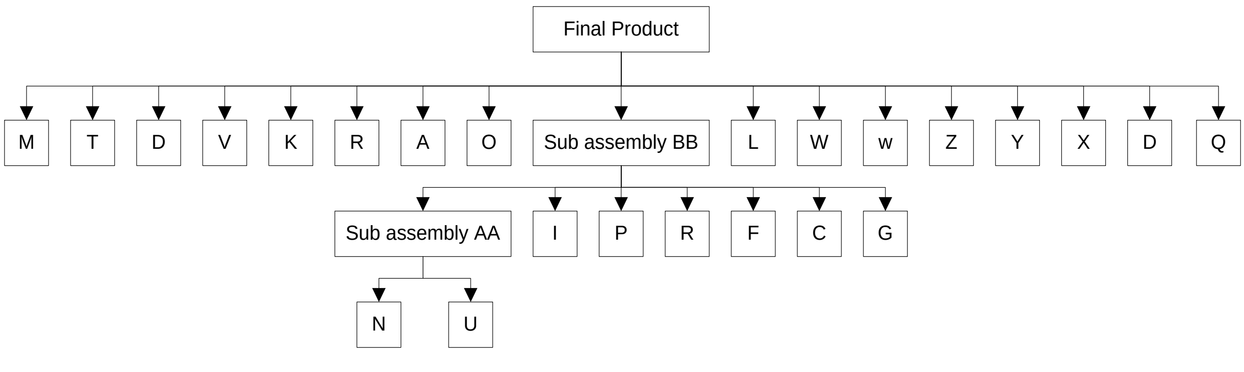

Figure 9. Bill of Material of Product "1"

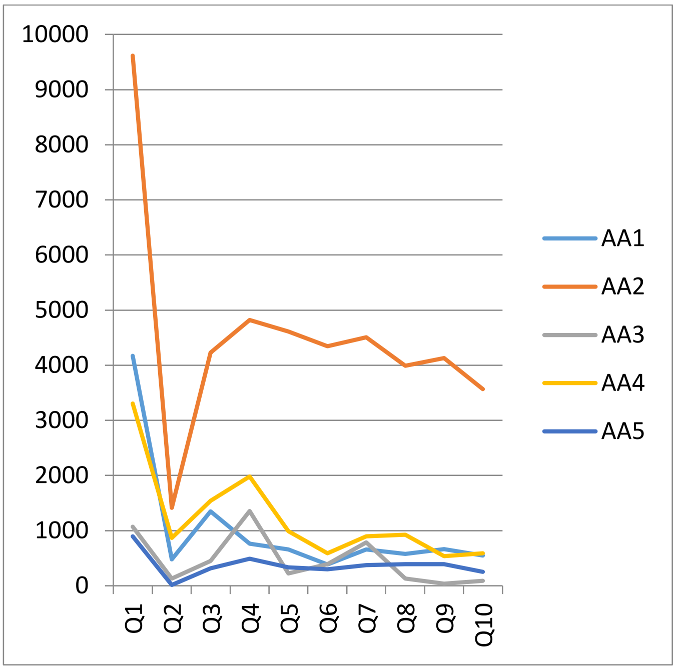

Figure 10. Demand of Sub Assemblies AA_1 – AA

In this case study, we only focused on the Sub Assembly AA_i and one of its components which is U_i. It is noted that to assembly one unit of AA_i is requiring 6 (six) units of U_i. Therefore following the MRP literatures, the Sub Assembly AA_i can be called as the part level 1 and the component Ui can be called as the part level 2.

3.2. Experiments

Total combination of 6 lot sizing techniques as presented in Table 3 are applied for determining the lot size of both part level 1 and part level 2.

The objective is to minimize total cost which comprises of ordering and holding cost. For a particular level and item, the total cost can be calculated as

$$TC_i = \sum_{j=1}^{n} \left(A_{ij} + h_i S_{ij} \right) \qquad (1)$$

Where

i : item index, i = 1, 2, 3, 4, and 5
j : time index, j = 1, 2, 3, …, 130
A_{ij} : ordering cost ($/order); = A_i (ordering cost of item i) if an order of item i is taken place at period j, = 0 otherwise
h_i : holding cost of item i ($/unit/week)
S_{ij} : inventory on hand of item i at period j (unit/week)

Except the Lot for Lot technique, in which an order is always taken place whenever there is demand in a given period, other lot sizing techniques have certain heuristic rule for determining the lot size, i.e. placing an order for fulfilling demand of several periods. The rules for each technique are presented here for reference:

a. Silver Meal 1 (SM1)

In the Silver Meal 1, the lot size is determined in order to minimize the sum of ordering and holding cost per period. The decision on order size at period p is being used for fulfilling the demand of n periods, i.e. from period p to $p+n-1$, in which the periodic cost is minimized. The minimization problem can be presented in the following equation

$$\min \frac{A + \sum_{j=p}^{p+n-1} \left(h \cdot S_j \right)}{n} \qquad (2)$$

b. Silver Meal 2 (SM2)

The rule of Silver Meal 2 is exactly the same with the rule of Silver Meal 1, to minimize the sum of ordering and holding cost per period. However, in this method zero demands are excluded from calculating the periodic cost.

Table 3: Combination of lot sizing technique

		Lot Sizing Technique for Level 1					
		LFL	**SM1**	**SM2**	**LUC**	**PPB**	**ICR**
Lot Sizing Technique for Level 2	**LFL**	√	√	√	√	√	√
	SM1	√	√	√	√	√	√
	SM2	√	√	√	√	√	√
	LUC	√	√	√	√	√	√
	PPB	√	√	√	√	√	√
	ICR	√	√	√	√	√	√

Figure 11. Excel Spreadsheet for Calculating Lot Size

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Setup Cost	$ 5.00											
2	Holding Cost	$ 0.0048											
3	Total Cost	$116.1440											
4													
5	Week	1	2	3	4	5	6	7	8	9	10	11	12
6	GR	0	0	0	34	127	138	104	106	183	179	105	91
7	SR	0											
8	POH	0	0	0	475	348	210	106	0	416	237	132	41
9	NR	0	0	0	0	0	0	0	0	0	0	0	0
10	PORec		0	0	509	0	0	0	0	599	0	0	0
11	PORel	0	0	509	0	0	0	0	599	0	0	0	0
12	SC	0	0	5	0	0	0	0	5	0	0	0	0
13	HC	0	0	0	2.28	1.6704	1.008	0.5088	0	1.9968	1.1376	0.6336	0.1968
14	SC+HC	0	0	5	2.28	1.6704	1.008	0.5088	5	1.9968	1.1376	0.6336	0.1968
15													

c. Least Unit Cost (LUC)

In the Least Unit Cost, the lot size is determined in order to minimize the sum of ordering and holding cost per unit items. The decision on order size at period p is being used for fulfilling the demand of n periods, i.e. from period p to $p+n-1$, in which the unit cost is minimized. The minimization problem can be presented in the following equation

$$\min \frac{A+\sum_{j=p}^{p+n-1}\left(h\cdot S_j\right)}{\sum_{j=p}^{p+n-1} D_j} \quad (3)$$

d. Part Period Balancing (PBB)

In the Part Period Balancing, the lot size is determined in order to minimize the difference between ordering and inventory holding cost. The decision on order size at period p is being used for fulfilling the demand of n periods, i.e. from period p to $p+n-1$, in which the difference is minimized. The minimization problem can be presented in the following equation

$$\sum_{j=p}^{p+n-1}\left(h\cdot S_j\right)\le A \quad (4)$$

e. Incremental (ICR)

The rule of Incremental technique is to make an order covers the nth demand if the incremental inventory holding cost incurred by doing so is less than or equal to the ordering cost. In other words, the decision on order size at period p is being used for fulfilling the demand of n periods, i.e. from period p to $p+n-1$, in which find the largest value of n that satisfying following equation

$$\sum_{j=p}^{p+n-1}\left(h\cdot S_j\right)\le A \quad (5)$$

In order to assist the experiments, an Excel spreadsheet is created based on Material Requirement Planning (MRP) calculation, altogether with some macros written in the Visual Basic for Application for implementing the rules for determining the lot sizing. The screenshot of the spreadsheet is presented in Figure 11. It is noted that unit ordering cost is filled in the cell B1, the unit holding cost is filled in the cell B2, and the demands of item are filled in the range B6:EA6. The total cost is calculated and presented in the cell B3. Six macros are written for each lot sizing techniques, in which the main procedures are reading the inputs (ordering cost, holding cost, and demand), calculating the lot size depend on each rule, and writing the lot sizes in the range B10:EA10.

Table 4. Total Cost Result for Level 1

Technique	Item					Total 5 Items
	AA_1	AA_2	AA_3	AA_4	AA_5	
LFL	590.00	635.00	380.00	565.00	560.00	2730.00
SM1	184.42	***399.20***	***112.95***	***209.54***	***123.54***	***1029.66***
SM2	***180.45***	400.26	116.14	212.80	124.97	1034.63
LUC	217.64	426.36	132.39	233.03	146.55	1155.97
PPB	191.99	412.83	125.92	224.55	130.90	1086.19
ICR	193.72	413.14	124.27	214.63	132.75	1078.50

Table 5. Total Cost Result for Level 2 Whenever Level 1

Technique	Item					Total 5 Items
	U_1	U_2	U_3	U_4	U_5	
LFL	590.00	635.00	380.00	565.00	560.00	2730.00
SM1	356.38	***602.76***	232.75	410.59	***271.60***	1874.08
SM2	***355.55***	***602.76***	***227.12***	***406.82***	274.68	***1866.94***
LUC	429.99	657.89	263.13	439.32	305.82	2096.15
PPB	400.55	709.48	245.45	446.54	286.68	2088.69
ICR	360.04	***602.76***	241.96	413.86	276.59	1895.22

Table 6. Total Cost Result for Level 2 Whenever Level 1 is Solved by SM1

Technique	Item					Total 5 Items
	U_1	U_2	U_3	U_4	U_5	
LFL	***115.00***	***250.00***	***75.00***	***120.00***	***75.00***	***635.00***
SM1	***115.00***	***250.00***	***75.00***	***120.00***	***75.00***	***635.00***
SM2	166.43	***250.00***	144.76	***120.00***	199.06	880.25
LUC	***115.00***	***250.00***	***75.00***	***120.00***	***75.00***	***635.00***
PPB	***115.00***	***250.00***	79.48	***120.00***	***75.00***	639.48
ICR	***115.00***	***250.00***	***75.00***	***120.00***	***75.00***	***635.00***

Table 7. Total Cost Result for Level 2 Whenever Level 1 is Solved by SM2

Technique	Item					Total 5 Items
	U_1	U_2	U_3	U_4	U_5	
LFL	***110.00***	***245.00***	***65.00***	***115.00***	***70.00***	***605.00***
SM1	***110.00***	***245.00***	***65.00***	***115.00***	***70.00***	***605.00***
SM2	165.72	***245.00***	183.30	***115.00***	130.99	840.02
LUC	***110.00***	***245.00***	***65.00***	***115.00***	***70.00***	***605.00***
PPB	***110.00***	***245.00***	***65.00***	***115.00***	***70.00***	***605.00***
ICR	***110.00***	***245.00***	***65.00***	***115.00***	***70.00***	***605.00***

Table 8. Total Cost Result for Level 2 Whenever Level 1 is Solved by LUC

Technique	**Item**					**Total 5 Items**
	U_1	**U_2**	**U_3**	**U_4**	**U_5**	
LFL	***110.00***	***250.00***	70.00	***125.00***	***75.00***	630.00
SM1	***110.00***	***250.00***	70.00	***125.00***	***75.00***	630.00
SM2	***110.00***	***250.00***	96.53	143.85	106.82	707.19
LUC	***110.00***	***250.00***	70.00	***125.00***	***75.00***	630.00
PPB	***110.00***	***250.00***	***68.17***	***125.00***	***75.00***	***628.17***
ICR	***110.00***	***250.00***	***68.17***	***125.00***	***75.00***	***628.17***

Table 9. Total Cost Result for Level 2 Whenever Level 1 is Solved by PPB

Technique	**Item**					**Total 5 Items**
	U_1	**U_2**	**U_3**	**U_4**	**U_5**	
LFL	***100.00***	***210.00***	***65.00***	120.00	***65.00***	560.00
SM1	***100.00***	***210.00***	***65.00***	120.00	***65.00***	560.00
SM2	***100.00***	***210.00***	189.29	135.72	106.43	741.43
LUC	***100.00***	***210.00***	***65.00***	120.00	***65.00***	560.00
PPB	***100.00***	***210.00***	***65.00***	***118.83***	***65.00***	***558.83***
ICR	***100.00***	***210.00***	***65.00***	***118.83***	***65.00***	***558.83***

Table 10. Total Cost Result for Level 2 Whenever Level 1 is Solved by ICR

Technique	**Item**					**Total 5 Items**
	U_1	**U_2**	**U_3**	**U_4**	**U_5**	
LFL	***115.00***	***255.00***	***70.00***	***125.00***	***75.00***	***640.00***
SM1	***115.00***	***255.00***	***70.00***	***125.00***	***75.00***	***640.00***
SM2	131.97	263.56	113.51	139.87	89.02	737.94
LUC	***115.00***	***255.00***	***70.00***	***125.00***	***75.00***	***640.00***
PPB	***115.00***	***255.00***	***70.00***	***125.00***	75.70	640.70
ICR	***115.00***	***255.00***	***70.00***	***125.00***	***75.00***	***640.00***

3.3. Results

Using ordering cost of $5/order and holding cost of $0.0048/unit/week for all items and levels, the total cost calculated for level 1 is presented in Table 4 and the total cost calculated for level 2 are presented in Tables 6–11. In those tables, the smallest total cost among techniques of each column is highlighted by bold and italic typeface. From Table 4, it is shown that the Silver Meal 1 (SM1) lot sizing technique is able to provide the smallest total cost for all items for level 1. Also, the Silver Meal 2 (SM2) is the second best lot sizing technique, in which the total cost for all items only slightly larger than the total cost of SM1, which is not more than $5 or 0.5%.

Based on Tables 5–10, for different lot sizing technique is applied for level 1 item, the best lot sizing technique for level 2 items can be summarized in Table 11. Observing the summary in Table 11, it seems that there is no single lot sizing technique that is consistently able to provide the smallest total cost for level 2 items across various lot sizing techniques applied for level 1 items. Finding these facts, one may realize that after lot sizing techniques are applied for the level items, the demand for level 2 items, which are shown in the gross requirement (GR) row in the MRP table, are in the form of lumpy demand.

Table 11. Summary of The Best Lot Sizing Technique for Level 2

Lot Sizing Technique for Level 1	Best Lot Sizing Technique for Level 2
LFL	**SM2**
SM1	**LFL, SM1, LUC, ICR**
SM2	**LFL, SM1, LUC, PPB, ICR**
LUC	**PPB, ICR**
PPB	**PPB, ICR**
ICR	**LFL, SM1, LUC, ICR**

Whenever the total cost of level 1 and level 2 for all parts are combined, however, the result is summarized in Table 12. It is implied that the total cost of both level are minimized whenever Silver Meal 2 lot sizing technique is applied for level 1 and any lot sizing technique except Silver Meal 2 is applied for level 2.

Table 12. Total Cost of Level 1 and Level 2 for All Parts

		Lot Sizing Technique for Level 1					
		LFL	**SM1**	**SM2**	**LUC**	**PPB**	**ICR**
Lot Sizing Technique for Level 2	**LFL**	5460.00	1664.66	***1639.63***	1785.97	1646.19	1718.50
	SM1	4604.08	1664.66	***1639.63***	1785.97	1646.19	1718.50
	SM2	4596.94	1909.90	1874.65	1863.16	1827.62	1816.44
	LUC	4826.15	1664.66	***1639.63***	1785.97	1646.19	1718.50
	PPB	4818.69	1669.13	***1639.63***	1784.14	1645.02	1719.21
	ICR	4625.22	1664.66	***1639.63***	1784.14	1645.02	1718.50

4. CONCLUSION AND DISCUSSION

From the two examples of the sales volume of two smart phones sold in a retailer, it can be concluded that the product life cycle is getting shorter. This actually confirmed of what have been stated by previous researcher such as Bayus (1994). This implies a situation that manufacturing face the situation of decreasing pattern of their product more often. For the case when manufacturer produce discrete product i.e. a product that comprise of several components and or sub-assembly, the decreasing demand pattern of the final product affect the decision that have to be made by a manufacturer related to the inventory policy for the component and the sub-assembly. If the company does not adjust their inventory policy to incorporate the changing of the product life cycle stage, i.e. the final product has already been in the decreasing stage however when the company do their Material Requirement Planning for the component and sub-assembly, they do not consider about the decreasing pattern, it might happen that the company will face the left over situation. Through the case study presented in the paper, it is concluded that a company should not consider only one component or one level whenever deciding the inventory policy, i.e. production lot size. It is shown by the case study that the best lot sizing technique for a particular parent of product whenever the company only consider the parent is different with the best lot sizing technique whenerver the company consider the parent and its child. For the case presented, it is shown that the smallest total coat of parent and child is most likely occured whenever Silver Meal 2 lot sizing technique is applied in the parent with decreasing demand pattern.

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