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Optimisation of Resin Production Quantity Using De Novo Programming Models

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ABSTRACT

PT. ABC is one of the well-known resin manufacturing companies that produces resin in large quantity. However, there is still residual production due to excess raw materials. The objective of this research is to find out appropriate combination of resin to be used in paint production, so that PT. ABC would achieve an optimal profit. The research method used to solve the problem is Forecasting Method and De Novo Programming. Besides, this research uses QM for Windows 2 software to support data analysis process. The results show that the demand forecast in December 2015 for each type of resin is: 240,146 kg (long type), 311,858 kg (medium type), 340,783 kg (short type), and 376.660 (other types). The combination of resin types to be produced that can optimise the production in December 2015 is: 240,146 kg (long type), 311,858 kg (medium type), 340.783 kg (short type), and 473.712,6 kg (other types). From this combination, PT. ABC would achieve optimal profit of Rp 6.388.886,315 or approximately Rp 6.3 billion.

Keywords: De Novo Programming, demand forecasts, linear programming, production quantity, profit

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INTRODUCTION

The paint industry in Indonesia is one of the emerging industries and according to TribunBisnis (2014), paint sales in Indonesia had increased 10% annually. It happened because of high consumer

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demand for paint in many areas for the purpose of painting the house and other properties. To meet consumer desires, paint manufacturers have made available wide selection of paint colours that can be selected according to consumer desire and wants. Paint industries in Indonesia must compete with each other to get consumers who are loyal to its paint products by doing new development and innovation in the manufacture of paint. Green coating is paint that is environmentally friendly and not hazardous to health.

According to the daily (Kompas, 2009), paint usually contained VOC (Volatile Organic Compound) material which could cause nerve reproductive disorders when it was inhaled. Therefore, the composition in the paint manufacture should also be considered for health reasons. Therefore, manufacturers understand t current need of consumers in order to get the desired market share.

One of the directors of Frost and Sullivan paints, Eugene van de Weerd, argued that the paint and coating industries are heavily depended on end users (Republika, 2010). The demand for paint comes primarily from the construction, shipping, automotive and furniture sectors.

Increasing the value of the paint market encourages the paint industries in Indonesia to be more productive. Data (MarsIndonesia, 2013) showed that from 2010 to 2013 the paint market value increased. Based on Indonesia Business Daily (2014), in 2010, the market value of paint in Indonesia reached Rp10.47 trillion and in 2011, it reached Rp11.37 trillion. In 2012, it was estimated the market value of this paint was not less than Rp12.57 trillion. The paint market in 2013 was worth Rp13.8 trillion and in 2014, it reached Rp15 trillion.

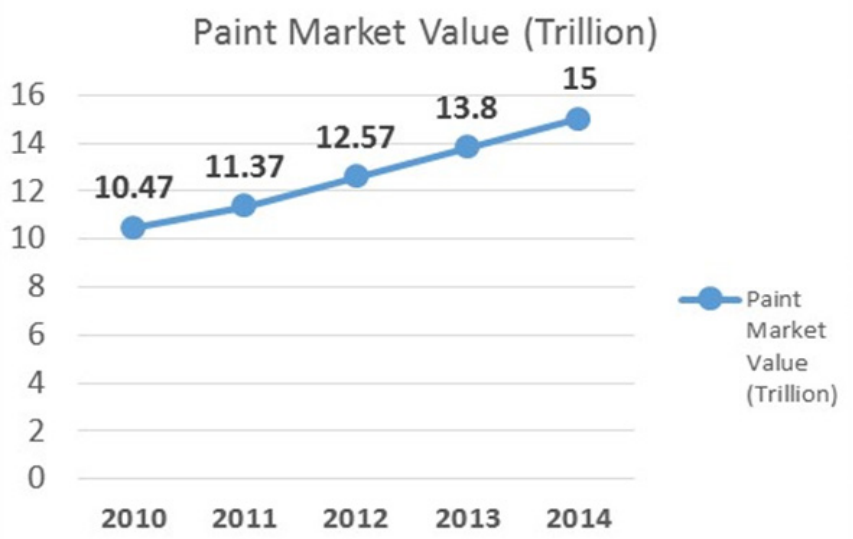


Figure 1. Paint market value
Source: Indonesia Business Daily, February 22nd, 2014

One of the main components of paint is resin which attaches the entire material to the surface. If there is no resin, the paint cannot be formed. Resins are made of sap produced by plants. When chemically processed, the resin is made with a mixture of oil (soya, coconut), chemical acids, polyols and reagents (reagent solution). Resin has a liquid, sticky and viscous form.

One of the well-known paint companies specialising in good quality of resin manufacturing is PT. ABC. This company has been certified with Quality Management System ISO 9001 and ISO14001 Environment Management System certificate for paint and resin unit. Its competitors are shown in Table 1.

Since resin is used for internal and external needs, PT. ABC produces it in large quantities. Therefore, PT. ABC uses common method to forecast the production capacity for the next period. As a result, there is still residual production due to the excess of raw materials on production every year (Table 2).

From the table, we can know that there is an excess of raw material for each period.

As a qualified and competitive company, PT. ABC must be able to manage the company's operations very well in order to increase sales volume and achieve the vision of PT. ABC to become the top 2 resin company in the industry in Indonesia. As described above, one of the obstacles PT. ABC is facing is the waste that occurs due to the excess of raw materials. This study hence focuses on ways to help PT. ABC determine the exact amount of raw materials with a predetermined budget so as to achieve maximum profit for the company. The current researchers used De Novo Programming analysis method using QM for Windows 2 and Microsoft Excel.

Table 1
The competitors of PT. ABC

Competitors		Resin Demand	
		2014	2015
1	ETERNAL BUANA	17689	15000
2	NUPLEX RESIN	16203	13500
3	PT. ABC	15588	12700
4	TUNAS SUMBER KREASI	14017	11500
5	PARDIC	13200	10500
6	INAC	9170	8000

Table 2
PT. ABC's production and sales (Year 2013-2015)

	Production				Sales				Residual			
Month	2012	2013	2014	2015	2012	2013	2014	2015	2012	2013	2014	2015
January	1203	1283	1467	909	1195	1182	1432	903	8	101	35	6
February	1213	1318	933	1470	987	1307	945	1441	234	11	-12	29
March	1460	1149	1246	1118	1580	1182	1239	1132	-120	-33	7	-14
April	844	954	1291	980	840	948	1145	842	4	6	146	138
Mei	1478	1028	1347	1176	1312	1111	1493	1280	166	-83	-146	-104
June	1489	1144	1565	1362	1660	1044	1481	1317	-229	100	84	45
July	967	1400	1346	1295	962	1462	1250	1335	5	-62	96	-40
August	1464	905	988	1500	1325	901	1187	1553	139	4	-199	-53
September	1277	1343	1348		1314	1371	1217		-163	-28	131	
October	981	1168	1466		903	1167	1462		78	1	4	
November	1495	1215	1190		1579	1144	1317		-84	71	-127	
December	730	1267	1471		715	1292	1420		15	-25	51	

LITERATURE REVIEW

Literature review consisted of the following:

Journal: Comparative Study on Forecasting Accuracy among Moving Average Models with Simulation and PALTEL Stock Market Data in Palestine (Safi & Dawoud, 2013).

Muniroh, Ismail and Lazim (2017) described that forecasting was an important tool to make decisions in a variety of fields. It helps government and top management of firms in their decision making for strategic planning purposes. There are differences in forecasting applications, such as in marketing where it plays a key role in determining the sales targets, pricing and advertising expenditure.

Umarusman and Turkmen (2013) explained that the De Novo Programming technique can be used to determine the optimum amount of production so as to maximise the company's profit. This paper explains that using De Novo Programming enables reduction of expenditure.

Taghrid and Fatma (2009) explained that demands might not be known before resources were acquired. The demand determines actual quantum of sales and revenue.

Gill, Murray, Saunders, Tomlin and Wright (2008) described his legacy of optimisation system in solving complex real-world problems. George B. Dantzig, also known as "GBD", was a famous for inventing the simple method for linear programming; foundational research on duality, complementarity theory, integer programming, quadratic programming, decomposition algorithms, stochastic programming, and methods for large specially structured linear programs; inspiring generations of students and colleagues; and shaping the entire field of optimization. Although George's lifetime achievements included a substantial body of deep theory, he derived his greatest professional satisfaction from the successful

application of theory to real-world problems.

Balogun, Jolayemi, Akingbade and Muazu (2012) explained that company managers often faced resource constraints. These resources may include men, materials and money. The problem is on deciding resource allocation to obtain the best result, which may relate to profit or cost or both. Linear Programming is heavily used in Micro-Economics and Company Management such as Planning, Production, Transportation, Technology and other issues.

Ezema and Amakom (2012) showed the application of linear programming method to optimise company profit using the case of Golden Plastic Industry which produced PVC pipes. Eight types of products should be produced in order to optimise company profit. These products are differentiated by their size, thickness and length. In producing these pipes, the company needs different materials in different combinations. The major raw materials used by the company in the production of the products include: Resin (the major raw material), Calcium carbonate, Tio 2, Stabiliser, Cast, Carbon black, and Blend. The result shows that there are only two sizes of the total eight "PVC" pipes. It also shows that there are only two of the raw materials –tio 2 and labour time- which were surplus, while the other six-resin, calcium carbonate, stabiliser, cast, carbon black and blend-were scarce in relation to the model.

According to Sarjono, Kusuma, Hamali and Mulyono (2016), their study used 2 stages of data processing to produce optimum production capacity planning for polyethylene plastic. The first phase is forecasting the demand for the next year. The second phase is conducting rough cut capacity planning (RCCP) that will provide alternative solution to meet consumer demand.

According to Maurya, Misra, Anderson and Shukla (2015), their study had the following recommendations: (1) The company should employ linear regression, linear trend and/or nonlinear regression and trend models to forecast its production capacity and sales, (2) It is clear that model-based decision is important for its accuracy and objectivity. But such decision-making approach is not widely used in practice. Qualitative decisions, such as subjective estimation, intuition and trial and error are commonly used by company. It is an eye opener to policy makers in the company to shift the model-based decision-making styles in general.

Based on Haider, Fareed, Tariq, Usman, Ud din and Sehrish khan (2016), their study used Linear Programming Technique in solving one of the paint company problems in Pakistan.

Lucey and Lucey (2002); Wagner (2007) suggested Linear Programming and operation research technique can be used in other sectors, such as airlines, agriculture, oil refining, education, energy planning, pollution control, transportation planning and schedule production planning, research and development, and health care system among others.

Zeleny (1998) explained Multiple

Criteria Decision Making (MCDM) that was an alternative concept of optimality where multiple criteria characterise the notion of optimal. It suggests that because there are no trade-offs along a single criterion, optimality is an essentially multi-criteria concept. Eight concepts of optimality were described in five complementary ways: (a) simple, real-life examples with a defined set of discrete alternatives; (b) formal (mathematical) statement of a general optimization problem; (c) graphical representation of two-dimensional linear-programming problems; and (d) simple numerical problem.

Chen and Tzeng (2009) recommended adopting an efficient alliances/allocation planning model as key for achieving the company's financial goals, especially relating to resource sustainability. This study showed the De Novo programming approach helped companies find an optimal resource allocation base for company's financial goal planning. The more advanced efficiency-planning model combines strategic alliances from different company's resources.

Choy and Cheong (2011) explained the existence of demand function so we could do the forecasting with the right techniques to forecast the demand for the next period.

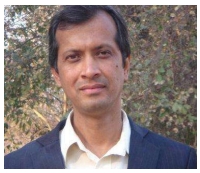
Safi and Dawoud (2013) discussed three methods for measuring the accuracy of forecasting: moving average, weighted moving average and exponential weighted moving average.

Aryani (2009) described techniques to overcome the problem of waste goods due to excessive production and excessive raw materials to maximise corporate profits.

Fiala (2011) described De Novo programming as a re-formulation of linear programming useful in providing pricing on resources and producing products within a budget.

Umarusman (2013) described Multi-objective Decision Making (MODM) technique as having an important role in solving decision-making problems which could include more than one objective functions.

There is no rule that states that it is compulsory for an NRI/PIO/OCI to get a PAN card. This is definitely not needed if you do not plan to invest large amounts of money in India. However, as per the latest government regulations, services like opening a new bank account in India, getting a new credit card, investing in the stock market in India or making a purchase of more than INR 50,000, the PAN card is mandatory. However, if you have no taxable income from India or your income is below the tax threshold, then you can make use of Form 80 in lieu of a PAN card. This will allow you to open bank accounts without getting a PAN card. Note



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that this option is only open to NRI/PIOs/ OCI holders.

It is not mandatory for an NRI / PIO to have a PAN for entering into a property transaction (as per Rule 114C). However PAN is required to repatriate the sale proceeds of the property out of India.

If constraint resources are not used at full capacity in a mathematical model, unused resources will lead to objectives not being realised. Therefore, it is very important to ensure that all objectives are realized at optimal levels, and limited resources are used at full capacity.

Based on the literature review of the journal, the study will forecast demand in advance the exact number of requests, after which a demand constraint will be used to calculate the combination of resin products produced with De Novo Programming and to determine the maximum profit that can be achieved by implementing this method.

The research will use 6 methods of forecasting (naïve method, moving average, weighted moving average, exponential smoothing, exponential smoothing with trend, and trend analysis) to test which method is the most accurate and to use forecasting result as comparison of researcher calculation with actual company. The most accurate forecasting result is determined with the smallest value of MAD and MSE.

The research also used three variables based on the De Novo Programming method (decision variables, constraint function, objective functions) to determine the right product combinations for each resin and to calculate the maximum profit that could be achieved by implementing this method. The results of the calculations of researchers will then be compared with the actual results of companies to find out whether the research conducted by researchers provided a positive effect for the company.

The main objectives of this research are to find out the: 1) right product combination to be produced by PT. ABC in December 2015 to optimise the profit of the company; 2) total profit obtained by PT. ABC.

MATERIALS AND METHODS

Primary data was obtained from interviews with Marketing Manager of PT. ABC in addition to conducting a survey of resin products made by PT. ABC. Secondary data was obtained from PT. ABC's annual sales report.

Operationalisation of Variables

In Table 3, unit and amount for resin is based on per Kg, the amount of production time is in Hour and profit is in Rp. In De Novo Programming units, operationalisation of variables can be different while in Linear Programming, the units are always the same.

Table 3
Operationalisation of variables

Variable	Indicator	Unit	Scale
Decision variables	1. Long Resin	Kg	Ratio
	2. Medium Resin	Kg	
	3. Short Resin	Kg	
	4. Other Resins	Kg	

Method of Data Processing and Analysis

Forecasting Method

In this study, researchers used demand data from January 2014 -August 2015. Data is obtained from Marketing Manager PT. ABC. From the data, forecasting calculation of demand for September 2015 was performed based on the following methods: Naïve Method, Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend and Linear Regression.

The optimal method was MAD (Mean Absolute Deviation) and the smallest MSE (Mean Squared Error) based on data in Table 4.

Table 4
Resin demand (January 2014-August 2015)

Month	Long	Medium	Short	Others
January 2014	282	314	389	482
February 2014	184	209	257	283
March 2014	255	281	333	377
April 2014	281	243	355	412
May 2014	298	282	276	491
June 2014	331	397	372	465
July 2014	257	412	309	368
August 2014	267	205	192	324
September 2014	257	321	371	399
October 2014	298	347	364	457
November 2014	298	342	195	355
December 2014	295	342	405	429
January 2015	206	216	227	260
February 2015	362	355	371	382
March 2015	197	238	299	384
April 2015	189	222	278	291
May 2015	184	281	341	370
June 2015	270	298	362	432
July 2015	261	301	342	391
August 2015	253	382	402	463
TOTAL	5225	5988	6440	7815

Source: PT. ABC (2015)

De Novo Programming Method

The result of demand forecast for December 2015 would be used to determine the obstacle function in De Novo Programming to find the optimum product combination that must be produced.

This research focuses on finding the optimum amount of production of four types of resin. Factors to be considered include the composition of raw materials, the availability of raw materials, the price of raw materials, and the selling price of each type of resin to be produced. This information is shown in Table 5 to Table 9.

Table 5
Raw material composition per unit product per kg

	Raw Material Solid 70 %			Solvent 30%	Longest Operation
Product	Oil	Dibasic Acid	Poly Alcohol		Time (LOT) hour
Long	0,504	0,14	0,023	SMT	26
Medium	0,35	0,161	0,035	SMT	24
Short	0,126	0,271	0,08	Xylene	20
Others	0,143	0,202	0,126	Xylene	28

Source: PT. ABC (2015)

Table 6
Availability of raw materials

Raw Material	Type	Availability (kg/year)
Oil	Long	840.000
	Medium	700.000
	Short	420.000
	Others	448.000
Total		2.408.000
Dibasic Acid	Long	378.000
	Medium	476.000
	Short	616.000
	Others	532.000
Total		2.002.000
Poly Alcohol	Long	182.000
	Medium	224.000
	Short	336.000
	Others	420.000
Total		1.162.000

Source: PT. ABC (2015)

Table 7
Raw material price

Raw Material	Price/kg
Oil	Rp8.491
Dibasic Acid	Rp27.000
Poly Alcohol	Rp24.300

Source: PT. ABC (2015)

Table 8
Resin selling price

Type	Price/kg
Long	Rp42.525
Medium	Rp42.525
Short	Rp39.690
Others	Rp55.890

Source: PT. ABC (2015)

Once the information in the aforementioned tables is obtained, the next stage is to determine the decision variables, objective function, constraints function.

Table 9
Decision variables, objective function, constraints function

Decision Variables	X1 = Long Type Resin, X2 = Medium Type Resin, X3 = Short Type Resin, X4 = Resin Type Others
Objective Function	Z=42.525X1 + 42.525X2 + 39.690X3 + 55.890X4
Constraints Function	Number of Raw Material Oil = 0,504X1 + 0,35X2 + 0,126X3 + 0,143X4 ≤ 2.408.000 Dibasic acid = 0,14X1 + 0,161X2 + 0,271X3 + 0,202X4 ≤ 2.002.000 Poly alcohol = 0,023X1 + 0,035X2 + 0,08X3 + 0,0126X4 ≤ 1.162.000
	Capacity of Production = X1 + X2 + X3 + X4 ≤18.000ton/year =18.000.000kg/year
	Raw Material Costs = 8.618,364X1 + 8.169,35X2 + 10.330,866X3 + 9.730,013X4 ≤ 102.736.928.000
	Demand of each Product: X1=239,54 tonne = 239.540 kg X2=311,8644 tonne = 311.864,4 kg X3=340,7989 tonne = 340.798,9 kg X4=376,4481 ton = 376.448,1 kg
	Time of Production = X1=26 hour/ton =0,026 hour/kg X2=24 hour/ton=0,024 hour/kg X3=20 hour/ton=0,20 hour/kg X4=28 hour/ton=0,28 hour/kg Operating hour per employee per year =8 hours x 300 days x120 employees =288.000 hours

RESULTS AND DISCUSSIONS

The results of this study are as follows.

Forecasting Method conducted by researchers with QM for Windows 2 has a high compatibility with the results of actual demand of forecasting in PT. ABC. This proves that the implementation of software QM for Windows can facilitate forecasting calculations of the company. Table 10 shows the comparison of the results of researcher forecasting and PT. ABC actual data. The result of forecasting shows that the demand for the next period is determined using the forecasting method that has the smallest MAD and MSE.

In addition, De Novo Programming method also produces better product combinations and results in optimal profit.

Table 10
Forecasting results for PT. ABC vs actual data

Resin Type	December 2015	
	Researcher's Forecasting Results	PT. ABC Actual Data
Long	240,1463	239
Medium	311,8577	312
Short	340,7827	340
Others	376,6601	376

From the combination of resin products, this will maximise the profit of PT. ABC to Rp6,388,886,315 or approximately Rp6.3 Billion.

Table 11
Production combination

Resin Type	Production
Long	240.146 kg
Medium	311.858 kg
Short	340.783 kg
Others	437.712,6 kg

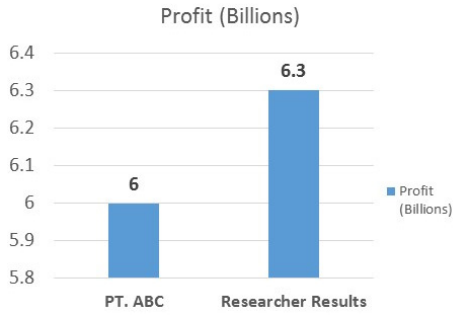

Figure 2. Profit comparison (PT. ABC vs researcher results)

CONCLUSION

By implementing forecasting method, the production results in December 2015 with QM For Windows 2 were 240,146 kg for long type resin, 311,858 kg for medium type resin, 340,783 kg for short resin, 376,660 kg other types.

The combination of products that can optimise the production of PT. ABC in December 2015 is 240,146 kg for long type resin, 311,858 kg for medium type resin, 340,783 kg for short type resin, and 473,712.6 kg for other types.

The total profit obtained by PT. ABC in December 2015 was Rp 6,388,886,315 or approximately Rp 6.3 billion.

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