Dynamic programming for an optimization of production plan

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Abstract. This study discusses the optimization of production plans in a convection company using a dynamic programming. Fluctuating demand requires the convection company to implement a strategy to control the production process so that there are no shortages or excess products. The purpose of this study is to find out the total minimum costs in preparation of school uniform production plans for the next one year using dynamic programming. The initial steps used in the production planning is predicting the demand of product from average demand in the previous 3-year period. The implementation of dynamic programming divides the problem into 12 stages due to monthly periods for one year. The results of this study obtained the total minimum cost of production plan for the next 1 year. The production plan through dynamic programming is able to maintain the existence of a convection company for the next few years.

1. Introduction
Indonesian people often use convection services in life. For example in a company, company employees must wear uniforms in working. In the field of education, students must wear school uniform every day. The convection services is really needed in many fields so that the convection business is very good to be a business for the people of Indonesia.

Convection business is one type of business that is developing in Indonesia. The development of the convection business is mainly due to two things. Firstly, because clothing is one of the basic human needs, so the market for the convection business will always be there. Secondly, because to start this business is not too large capital. One can start a convection business with only a few sewing machines. Where the sewing machine is one of the cheapest production machines [1].

Based on preliminary surveys on the production of clothing convection, it appears that the production planning carried out by the company has not been based on good management principles because sometimes there is an excess or a shortage product. Excess products will result in capital being embedded and causing losses. While a shortage of stock will result in customer dissatisfaction. Therefore, we need a method that can be used to solve the problem of production planning. A production planning is part of operation research. Operations research is an interdisciplinary group approach to achieve optimal results [2].

Optimization is a process to achieve optimal results. A company is trying to achieve maximum profit for the survival of the company and the development of the company itself. Before producing one product, a company need a material requirement planning [3]. In addition, the company also strives to survive in competition with other companies. Therefore, companies need to maintain the quality of the
products produced and manage their production management properly. Mathematics is a tool to simplify presentation and understand this problem. In mathematics, a problem can be presented, understood, analysed, and solved simply. The most important thing is to make a mathematical formula or model of the problem. One branch of mathematics that is useful in everyday life is operations research in dynamic programming [4]. Conceptually, dynamic programming is broader than most mathematical models and methods in operations research. In dynamic programming there is no standard mathematical formulation.

Dynamic programming is a technique that can be used to solve many optimization problems. In most applications, dynamic programming obtains solutions by working backward from the end of a problem toward the beginning, thus breaking up a large, unwieldy problem into a series of smaller, more tractable problems [5]. In this technique, decisions regarding a problem are optimized gradually and not all at once. This divides one problem in a several parts of a problem which in dynamic programming is called a stage, then is solved. The optimal decision over all stages is then called the optimal policy.

Based on the problems that have been explained, this research want to find out the total minimum costs in preparation of school uniform production plans for the next one year using dynamic programming so that the company is able to maintain the existence of a convection company for the next few years.

2. Methods

2.1. Data availability and research location
Data used for this research are primary data obtained from interview to the owner of the convection company, that is Toko Suskses di Kota Bengkulu and secondary data obtained from books, literatures and company’s financial statements. Data needed in this research include data for product demand from May 2011 to April 2014, storage cost, variable cost and setup cost

2.2. Research procedure
The steps of this research procedures are:

- Forecast product demand
- Calculate production planning using dynamic programming methods:
  - Determine stage: stage for this research divides to the 12th stage moves backward to the next stage, which is stage 1 which is seen in the monthly period in the next 1 year; determine state, determine the decision variable, cost variable (set up cost and production cost), determine the appropriate recursive relationship dynamic programming (recursive), calculate of data based on recursive relationships obtained to obtain optimal results.
  - Make a conclusion

3. Results and discussion

3.1. Forecast product demand
Based on school uniform demand data for May 2011-April 2014, seen that there is a fluctuation in demand for school uniforms for each month and the highest demand is in July and December due to school holidays. This study uses a product demand forecasting method that is seen from the amount product demand 3 years before. The purpose of forecasting is to predict number of product requests for school uniforms from May 2014 to April 2015.

3.1.1. Choose a forecasting method. Forecasting method used is a constant average method seen from the previous data period.

3.1.2. Calculate of demand forecasting. Calculation of demand forecasting with the constant average method can be described in the following formula:
where:

\[ \bar{d}_t = \frac{\sum_{i=1}^{n} d_{ti}}{n} \]  

\[ d_{ti} \] : number of requests per month  
\[ t \] : 1, 2, 3, ...  
\[ n \] : number of time series used

The result of forecast product demand can be seen at the Table 1 below.

| No | Month      | ES  | JHS | SHS | Total |
|----|------------|-----|-----|-----|-------|
| 1  | May 2014   | 712 | 570 | 505 | 1787  |
| 2  | June       | 766 | 617 | 613 | 1996  |
| 3  | July       | 775 | 611 | 599 | 1985  |
| 4  | August     | 622 | 655 | 521 | 1798  |
| 5  | September  | 610 | 470 | 581 | 1661  |
| 6  | October    | 573 | 590 | 619 | 1782  |
| 7  | November   | 665 | 607 | 608 | 1880  |
| 8  | December   | 738 | 595 | 643 | 1976  |
| 9  | January 2015 | 638 | 669 | 563 | 1870  |
| 10 | February   | 680 | 617 | 487 | 1784  |
| 11 | March      | 621 | 586 | 558 | 1765  |
| 12 | April      | 696 | 580 | 589 | 1865  |

Table 1 shows the results of calculations for the number of demand forecasts for elementary, junior high and high school uniforms from May 2014 to April 2015.

3.2. Production planning with dynamic programming methods

The results of forecast product demand in Table 1 are used to arrange production using dynamic programming methods in determining the amount of production must be done in each period in order to obtain the minimum costs in the next process production. In this research, the dynamic programming method is used because it is a mathematical technique used for optimize the decision making process in stages [5].

This production planning uses the dynamic programming method based on the results of the backward step, so the calculation starts from the 12th stage move back to stage 1 with a period of stages is the month. The recursion formalizes for this problem use backward procedure:

\[ f_t(i) = \min_j \{ c_{ij} + f_{t+1}(j) \} \]  

where:

\[ t \] : t-month  
\[ c(x) \] : the cost of producing a pair of school uniforms in a period  
\[ f_t(i) \] : minimum cost to meet demand for the t-month, t + 1, ..., 12 when put on a uniform at the beginning of the month

3.3. Variable costs

Variable costs are costs whose value increases or decreases with increasing or decreasing production. Thus, variable costs can be defined as the type of costs that change with changes in number of production. The pattern of increase or decrease in total variable costs due to decreasing or increasing total production can be translated into linear line equation functions as follows:
\[ Y = b X \]  

where:

- \( Y \): Total variable cost
- \( b \): Total pairs of uniforms produced
- \( X \): Variable pairs of uniform costs

3.4. The calculation of dynamics programming

This procedure is the last step in solving the problem of production planning to get the optimal profits in the next 1 year. Preparation of planning production by determining the minimum total cost using programming dynamic in the planning period of 1 year with a period of 1 month. Therefore, there are 12 stages of the implementation of the calculation that began from May 2014 to April 2015. Optimal solutions will be obtained based on the total minimum production costs obtained from each alternative production policy prepared. The calculation results on stage 1 as follows:

| \( f_1(i) \) | \( x_1(i) \) |
|-------------|-------------|
| \( f_1(0) \) = 1324314 | \( x_1(0) \) = 1.8 |
| \( f_1(0,1) \) = 1322916 | \( x_1(0,1) \) = 1.7 |
| \( f_1(0,2) \) = 1321518 | \( x_1(0,2) \) = 1.6 |
| \( f_1(0,3) \) = 1320120 | \( x_1(0,3) \) = 1.5 |
| \( f_1(0,4) \) = 1318722 | \( x_1(0,4) \) = 1.4 |
| \( f_1(0,5) \) = 1317324 | \( x_1(0,5) \) = 1.3 |
| \( f_1(0,6) \) = 1315926 | \( x_1(0,6) \) = 1.2 |
| \( f_1(0,7) \) = 1314528 | \( x_1(0,7) \) = 1.1 |
| \( f_1(0,8) \) = 1313130 | \( x_1(0,8) \) = 1.0 |
| \( f_1(0,9) \) = 1311732 | \( x_1(0,9) \) = 0.9 |
| ... | ... |
| \( f_1(1,9) \) = 1297758 | \( x_1(1,9) \) = 0 |

Table 2 show the result of the production planning scheduling using dynamics programming methods. Optimal production planning scheduling can minimize the total costs in the production process. Accordingly, from the results optimal production schedule planning calculations using dynamic programming raises the minimum total production cost of Rp 1,324,314,000.00 with producing 1,800 pairs of school uniforms in May, 2000 pairs in a month June, 1800 pairs in July, 1700 pairs in August, 1800 pairs in September, 1800 pairs in October, 1900 pairs in November, 2000 pairs in December, 1900 pairs in January, 1800 pairs in in February, 1800 in March and 1900 in April.

4. Conclusion

The mathematical model of the problem of production planning by predicting production demand in the coming year uses the constant average method and optimal solution through dynamic programming calculations. The mathematical model is a procedure in determining the minimum total cost in the production process of the monthly period for the next 1 year using dynamic programming.

The application of mathematical models to the case in the previous three years demand data has resulted in production planning for the coming year. Thus it can be decided that production can be continued with minimize production costs.
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