Price Quoting Method for Contract Manufacturer

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Abstract—This is an applied research to propose the method for price quotation for a contract electronics manufacturer. It has had a precise price quoting method but such method could not quickly provide a result as the customer required. This reduces the ability of company to compete in this kind of business. In this case, the cause of long time quotation process was analyzed. A lot of product features have been demanded by customer. By checking routine processes, it was found that high fraction of quoting time was used for production time estimating which has effected to the manufacturing or production cost. Then the historical data of products including types, number of components, assembling method, and their assembling time were used to analyze the key components affecting to production time. The price quoting model then was proposed. The implementation of proposed model was able to remarkably reduce quoting time with an acceptable required precision.

Keywords—Price quoting, Contract manufacturer, Stepwise technique, Best subset technique.

I. INTRODUCTION

PRICE quoting is one important process for contract manufacturing [1]. The quoting process would need good cooperation from the various sections of company. Therefore, it is time consuming process. In manufacturing industry, high fraction of the prices is from production section as it has been affected by lead time or production time. The more the difficulty of lead time determination, the longer the quoting time will be [2], [3]. To keep and satisfy the potential customer, a quick and accurate price quotation should be achieved whenever the customer request for a bid. Having the suitable quoting method would raise the efficient price quotation and customer satisfaction, consequently. The more the component of product, the difficulty of price estimating would be. Therefore, a lot of aiding methods have been conducted. A numbers of researches for price and/or cost quotation were listed and found that they have been usefully conducted via a computer based model [4]. But this work will proposed a method to construct a simple model of price quotation.

II. PROBLEM BACKGROUND

The case of interest is the contract electronic manufacturer providing the repair service and product made by order. The customers will demand to know the price of the service within a short period before signing a contract. The process of price quoting is displayed in Fig. 1. There are 7 main steps. Price quoting is started by receiving the order from the customer. In the next step, the data of purchasing is determined including product structure, data file, special process requirement, the number of product and the due date of price quoting. Then the product is determined in deep detail before it is designed. After that the production time is determined since it affects to labor and indirect labor and overhead cost. All details are rechecked again for an accurate data and the price is quoted, consequently.

![Fig. 1 Price quoting flow](image)

There are a lot of customers and product styles that required a due. The complexity is that the produced product has a lot of components, then, a lot of processes are required. In this case, it was found that the case of interest could not quote the price in time as customer required, especially for the new product. This problem also affects to the competitive ability of the company if the competitor has higher ability on this issue.

Currently, the price is quoted in the standard form using computer worksheet. From historical data, this method has provided a precise result but it took much time to start price
computing or quotation. The average quoting time required by
customer was 1.5 day/product, approximately but it takes at
least 3 days, currently. Therefore, the alternative quoting
method that could consume shorter time and provide accurate
result should be interested.

III. METHODOLOGY

Price quoting process is time consumer process. If the
factor affecting such time could be determined, then the
suitable method would be constructed. In this case, this work
started by determining such factors. The cause effect diagram
will be used as it is one of 7 tools providing a root cause
analyses. After the primary effects are declared then, they will
be analyzed using statistical analyses. Two statistical
techniques including best subset and stepwise will be used to
propose the quoting model in this work.

A. Best Subset Technique

The best subset is a technique used for statistically
determining regression models. It is used to determine which
variables should be included in a multiple regression model.
Usually, F-test, R square adjusted R square or Mollow Cp is
considered [5].

B. Step Wise Technique

Step wise regression is the statistic procedure to select the
model when there are a large number of potential variables
and when the selected model has no theory to base on [5].
Usually, F-tests are considered but possibly for t-tests, or
adjusted R-square. The form of interest here is determination
of variation on a forward selection. At each stage in the
compute process, after a new variable is added, a test is
performed to determine if some variables can be cut off
without increasing the residual sum of squares (RSS). The
procedure is terminated when the measure facto is optimized,
or when the available improvement falls below the critical
value [6].

C. Research Flow

Even though there are many types of product produced by
the company of interest but they can be divided into a group
based on their feature. Such feature includes the components,
size, and etc. This work started by considering the most
wanted alike products and used their quoting data to propose
the new method of price quoting. From Fig. 1 and working
information, it was found that the production time estimating
step consumed highest fraction of time in quoting process.
Such times were also changed when the product feature was
changed. The quoting times of the other steps were not
significantly different as they were routine process, then, their
quoting time were determined as a constant value. In this
case, it was useful if the factors affecting to production time
estimating could be declared. Therefore, the statistical
analyses were applied. The price quoting model, then, were
determined using best sup-set and stepwise techniques. Both
models were validated via the former quoting data. The most
suitable model provided lower error. Therefore, the results
were compared via mean absolute percent error (MAPE) [5].

Finally, the selected model will be implemented for upcoming
order while the old quoting method was also parallel
performed. This could validate the effectiveness of the new
quoting method. The flow of this work is concluded in Fig. 2.

![Fig. 2 Flow of Price Quoting Model Development](image-url)

IV. DATA ANALYSES AND RESULT

A. Quoting Time Factors

From part C in session III, the quoting time mainly
depended on the determination of production time. In this
case, the factor affecting to the production time estimation
was firstly determined. Based on the historical working data, it
was found that the feature of product has affected to the
production time estimating. The more the complicated feature
needed longer the production time. This also affected to the
difficulty of time estimating and to price quoting time,
consequently. From historical data study, most of products
were made in various sizes and from various types of
components. Those components were manually or
automatically assembled. In this case, it was concluded that
there were 6 factors affecting to production time. The first one
was area of product (A) affecting to an inspection time. The
second one was the number of component placed by automatic
machine (B). Even though the machine was used but it was
able to assemble one component at a time. The third and the
fourth one were the number of manually placed component (C)
and the number of mechanic component (D), respectively.
There was one component placed at a time and manual
inspection required. The fifth one was the number of terminal
(E) affecting to the soldering time. The final one was the
number of packing component (F).

B. Potential Factor Determination

The assembling data of the group of interested product in
the part were categorized based on the six factors of interest.
The number of sample size was 30 for being satisfied the
statistical view. First, the data properties such as normality
and residual value were analyzed as shown in Fig. 3 and Fig. 4.

Fig. 3 Normality plot of production time data for various levels of factors

Regression Analysis: Assembly time versus PCB area, Total Comp., ...

The regression equation is:

$Y = 0.277 + 0.000005A + 0.000586B - 0.00370C + 0.00733D - 0.000145E - 0.00531F$  \hspace{1cm} (1)

This regression model provided low deviation at 0.0097 and quite high R-sq at 84.6% (better than before data correction).

Further determination found that factor B (number of component placed by automatic machine) and E (number of terminal) had high variance inflation factors (VIP) showing that these two factors are not independent from each other. Therefore, the techniques of best subset and stepwise would be used to further determine the most potential affecting factors.

C. Quoting Model by Best Subset Technique

The potential factors counted for estimating production time were determined in this stage. By applying the best subset technique...

Fig. 5 shows that the data distribution is normal. Then, further analysis was performed as shown in Fig. 6. It was found that the relationship between assembly time in hour unit (Y) and their affecting factors was determined as in (1);

$Y = 0.277 + 0.000005A + 0.000586B - 0.00370C + 0.00733D - 0.000145E - 0.00531F$  \hspace{1cm} (1)

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Fig. 6 Regression Analyses after data correction
subset technique, the result was given as in Fig. 7. From (1), the regression shows the effect of all six factors. Therefore, the variables were grouped as the subset. There were 11 groups of variable considered for each case. Vars 1 meant that one variable was considered. In this case, it was found that the lowest Mallow C-p value was seven. Under such consideration, the lowest standard deviation and highest R-sq were achieved. Therefore, all six variables should be considered. Then, (1) should define the production time estimating equation.

\[ Y = 0.177 + 0.000006A + 0.00751D - 0.00763F \]  

Based on (1) all factors should be considered but only three factors required from (2). These two models, then, were validated and their results were compared via the historical data by MAPE determination. It was found that (2) provided lower MAPE than (1). In this case, (2) should be used for assembly time determination in price quoting process.

V. DISCUSSION

The main effect of price quoting time of the case of interest was from production time or lead time estimation as mentioned before [2] [3]. The complexity of production process depends on the feature or the components of such product. This also affects to the production time as the process and cost are sequence-dependent [7]. High error of production time estimating leads to inaccurate price quoting. As it is difficult to get an exact production time for the new product,
the estimating time could not be avoided. This work proposed production time estimating equation using two techniques. Their statistical analyses results were concluded in Table I.

<table>
<thead>
<tr>
<th>Items</th>
<th>Best Subset</th>
<th>Stepwise</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>0.00967932</td>
<td>0.0109104</td>
</tr>
<tr>
<td>R-Sq</td>
<td>84.6%</td>
<td>77.40%</td>
</tr>
<tr>
<td>P-value (ANOVA)</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>P-value (Factor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCB area(mm.2)</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Total Comp (SMD)</td>
<td>0.13</td>
<td>-</td>
</tr>
<tr>
<td>Total Comp (Manual SMT)</td>
<td>0.124</td>
<td>-</td>
</tr>
<tr>
<td>Total Comp (Mechanic)</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Total terminal</td>
<td>0.017</td>
<td>-</td>
</tr>
<tr>
<td>Packing</td>
<td>0.041</td>
<td>0.002</td>
</tr>
<tr>
<td>VIF (Factor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCB area(mm.2)</td>
<td>3.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Total Comp (SMD)</td>
<td>30.8</td>
<td>-</td>
</tr>
<tr>
<td>Total Comp (Manual SMT)</td>
<td>1.7</td>
<td>-</td>
</tr>
<tr>
<td>Total Comp (Mechanic)</td>
<td>3.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Total terminal</td>
<td>32.9</td>
<td>-</td>
</tr>
<tr>
<td>Packing</td>
<td>3.7</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Best subset provided the production estimation equation as in (1) whereas the stepwise gave the equation as in (2). The MAPE analyses found that the time estimating model was defined by (2) providing more precise result as its error was lower and less than 10% (4-9%) which is in the customer acceptable value.

The implementation of (2) for the new product found that the price quoting time was much shorter than the original method, as shown in Table II. The first two steps were the communication with customer. They were routine processes and theirs times were quite constant, averagely. In the third and the fifth steps, the original method spent much longer time as it was found that there were only 3 potential factors affecting to the product, according to (2). In this case, it was not necessary to estimate in all detail of product and its production process. A new design stage was not required as the products were already grouped and only potential time-effect component were required. As the price estimating structure is easier then it is easier to check the quotation at the final stage.

<table>
<thead>
<tr>
<th>Quoting Step</th>
<th>Original Method (Hr)</th>
<th>Proposed Method (Hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive order</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Check data</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Define data</td>
<td>6.5</td>
<td>0.83</td>
</tr>
<tr>
<td>Design</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td>Estimate production time</td>
<td>8</td>
<td>0.17</td>
</tr>
<tr>
<td>Check Result</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>4.5</td>
</tr>
</tbody>
</table>

By following this research flow, the production time of a specific group of product would be analyzed in the specific form. The price quotation of any product, then, could be performed faster for the company of interest.

REFERENCES