Unstable market forecasting and management techniques for a precast component fabricator

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Abstract

This paper discusses that it is necessary to develop proper methodologies to ensure the stable production rate in a prefabrication factory under the fluctuation of the demand, in order to succeed in the implementation of automatization and robotization in the factory. Authors applied the fuzzy theory to estimate the forthcoming order at the sales division. The fuzzy functions quantify the salesmen's forecasts and transform them into the value of future market trend. With it authors developed the methodologies to stabilize the daily production volume by controlling the sales strength, the markup, and the production schedules. The above methodologies have been implemented in a prototype system on MS-Windows platform and it has been verified that the methodologies are useful for the factories to maintain the stable production rate with highly advanced production lines.

1. INTRODUCTION

Construction demand is largely affected by the economic climate. As a result, construction companies must be prepared for periodic fluctuations in demand. For building component fabricators who have made substantial capital investments in automated production lines, those investments can present a major burden as demand fluctuates.

To achieve high operating rates, these companies must be able to accurately forecast demand trends and have a management method capable of stabilizing fluctuations in production volume in the factory.

This paper discusses forecasting methods and management methods designed to minimize demand fluctuations and guarantee high operation rates. The authors applied fuzzy logic to predict future orders for the sales division. Fuzzy functions were used to model sales division forecast and predict future production volume. The authors also applied management techniques to stabilize production volume by adjusting sales division strength, markup, and production schedules. These techniques were applied in a simulation representing the business performance of a precast concrete component fabricator.

2. DEMAND FLUCTUATIONS AND INVESTMENT IN PRODUCTION FACILITIES

2.1 Effect of Demand Fluctuations on Plant Productivity

In the building component sector, many companies are reluctant to make even small investments in mechanization, much less the large investments required for the automation of production lines. To keep their own payrolls as small as possible, these companies typically use temporary workers and subcontract jobs to outside firms. This kind of policy discourages companies from investing in automation, despite the fact that the technology is already feasible. As a result, they still depend upon obsolete production lines with low productivity.

This negative attitude towards capital spending is a major obstacle to the acceptance of mechanized and automated production lines in the building component sector. The development of new technologies and the stabilization of factory operating rates are critical to success in automation and the introduction of robotics.

To improve the productivity in the precast concrete industry, many research works have been carried out in forecasting demand and managing production.[1),2),3)]

2.2 Stabilization of Production Volume

Despite seasonal and economic fluctuations in demand, a building component factory must work towards a stable daily production volume. The greater the ratio of production line depreciation to total production costs, the more important a stable production volume becomes.

To stabilize production volume, manufacturers must forecast future demand trends, adjust the volume of incoming orders, and set up stable schedules for the production line. This must be carried out in several phases. In the sales division phase, it might be necessary to reallocate sales staff, adjust the prices offered clients, and negotiate delivery dates to reduce disparities in daily production volume.

In the production phase, methods that can be used to minimize this variance include line speed, production sequence, and the production lines used for the product. In some cases, the reallocation or layoff of workers might be necessary to balance production capacity and demand. So might the installation of additional lines or the scrapping of existing ones.

Figure 1 shows that fluctuations in construction demand can be reduced by stabilizing production volume in the sales and production divisions.
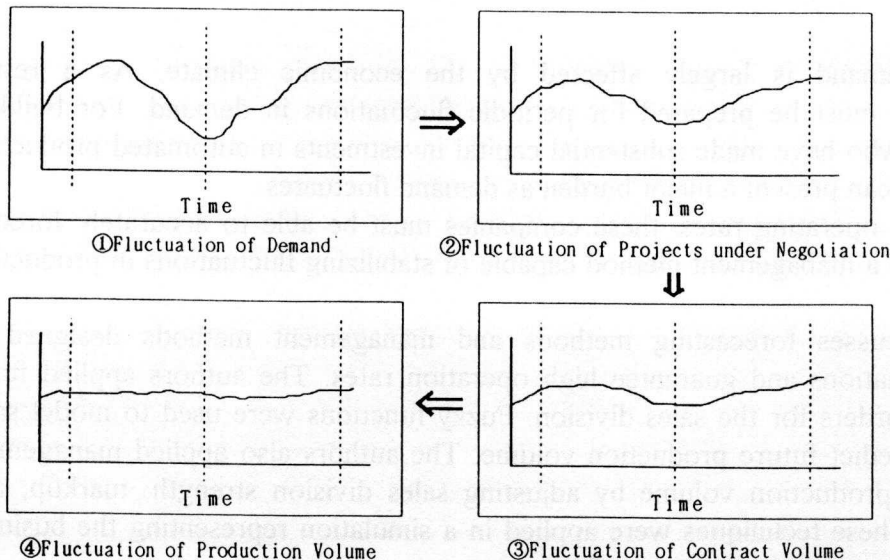

①Fluctuation of Demand   ②Fluctuation of Projects under Negotiation

④Fluctuation of Production Volume   ③Fluctuation of Contract Volume

Fig. 1 Reduction of Demand Fluctuations

3. FORECASTING PRODUCTION LOAD

3.1 Necessary Data

Production load can be estimated by forecasting future orders and calculating the load of current projects in process.

These data can come from construction demand forecasts and daily reports from the sales division. Normally, the accuracy of the forecast depends on the period of projection. The production load estimate consists of short-, mid- and long-term forecasts as follows:[4]

1. Estimate based on projects received (V1t)
2. Estimate based on projects under negotiation (V2t)
3. Estimate based on construction demand forecasts (V3t)

These estimates are combined to predict future production load. Estimated load at time t is equivalent to the sum of these three estimates at time t:

$$Vt = V1t + V2t + V3t \text{---------------(1)}$$

3.2 Estimate Based on Projects Received

Estimates based on projects received provide the most accurate data for estimating production load. Drawings and specifications offer detailed, sophisticated data for calculating production volume and schedules. Production load(V1t), however, covers only the immediate future, and its amount declines according to the time horizon shown in Fig. 2, because projects received will start in two to six months and be completed within a year.
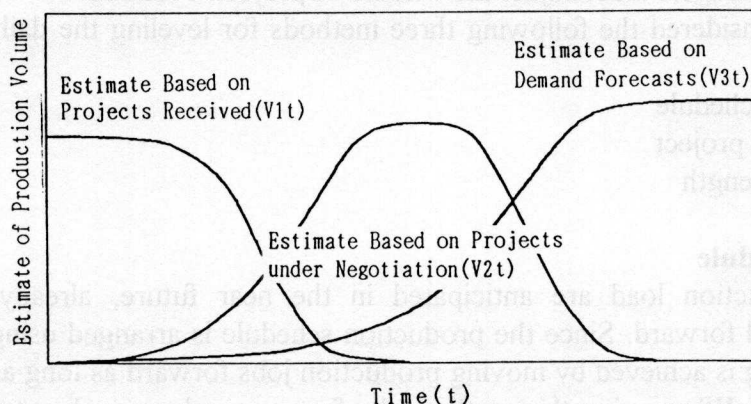

Fig. 2 Estimations of Production Load

3.3 Estimate Based on Projects Under Negotiation

The sales division is constantly negotiating a number of prospective projects. These offer valuable data for estimating future production load.

Whether a contract will be awarded is based on numerous factors such as price and delivery date. The company should utilize the factors under its control to achieve a price and delivery schedule that will help to balance future production capacity and load.

Projects currently under negotiation will start within a few months, thereby increasing and declining the factory's production load(V2t) in a certain period of time, as shown in Fig. 2.

3.4 Estimate Based on Construction Demand Forecasts

For estimates that are longer in range than the two described above, construction demand forecasts for specific market segments generally provide the most useful data. If there is a clear relationship between construction demand and the number of deals being negotiated,

construction demand forecast data could be valuable in estimating future production load. Fig. 2 shows an estimate for a situation in which production load(V3t) is expected to increase after a certain period, with fluctuations, in line with construction demand.

3.5 Quantifying Uncertain Data

In the sales division, two techniques are used to quantify the degree of uncertainty included in project: probability theory and fuzzy theory. Estimation of production load using uncertain information can be done using empirical techniques. It would be difficult for managers to determine distribution from a given uncertainty of the event using a probabilistic model.

Fuzzy logic is more understandable by and acceptable to managers than probability theory. When estimating the volume of panels required for a project whose details have not been decided, managers should take into account the uncertainty at that moment. To describe this uncertainty, the manager estimates the possibility of each volume that might occur. For example, they might assign a rating of 1.0 for complete certainty and 0.0 for absolutely no possibility.

4. LEVELING THE PRODUCTION LOAD

4.1 Leveling Methods

Construction demand is largely a captive of economic trends, seasonal effects, and random market phenomena; production load, meanwhile, fluctuates according to demand. To minimize these fluctuations, factory managers must arrange production lines and determine the best product sequence, while sales managers must adjust the volume of projects received.

In this paper, the authors considered the following three methods for leveling the daily production load:
    1) Adjusting the production schedule
    2) Adjusting markup for each project
    3) Adjusting sales division strength

4.2 Adjusting the Production Schedule

If fluctuations in the production load are anticipated in the near future, already-scheduled production must be moved forward. Since the production schedule is arranged using the Latest Start/Finish policy, leveling is achieved by moving production jobs forward as long as the necessary resources are available. When using this method, the factory needs enough extra space to store components produced ahead of schedule.

4.3 Adjusting Markup

If fluctuations are expected in the mid-term, two methods are available. One is to adjust markup based on the difficulty of obtaining the contract. Sine the typical industry markup will vary depending on business conditions, the company should use a relative markup representing the difference with the prevailing industry rate.

4.4 Adjusting Sales Division Strength

The other method for leveling production load in the mid- to long term is to adjust the capacity of the sales division to generate new orders. This is done by increasing staff and expanding sales areas. There is a direct correlation between sales division strength and the number of project proposals. Although there is no direct relationship between the number of proposals and production load, more proposals means more business opportunities, and the

establishment of an appropriate markup afterward would lead to a level production load in the long term.

4.5 Methods of Production Leveling

The three methods described above are designed to leveling production load in the future. These methods entail various costs. Shifting production forward requires additional factory space to store finished products awaiting delivery. Adjusting markup has a direct effect on company revenues and comes in two forms: markup is either raised to reduce the number of projects or lowered to boost sales. Adjusting sales division strength entails restructuring costs.

5. SIMULATION OF A PRECAST CONCRETE COMPONENT FACTORY

5.1 Model of a Precast Concrete Component Factory

To study the effectiveness of the techniques described above in estimating and stabilizing production load against fluctuations in construction demand, the authors developed a conceptual model to represent the performance of a precast concrete component factory.

In this model of a prefabrication factory, managers adjust sales division strength to keep project proposals at a steady level and adjust markup to control the number of projects accepted. These adjustments are made based on estimates or anticipated production volume. In the production phase, managers schedule production to maintain a constant load.

Hypothetical construction demand trends were input, and the model simulated the final production load as stabilized by the leveling techniques described above.

In this model, each project was represented by four characteristic attributes:
1) Possibility of receiving contract
2) Date of first delivery
3) Length of production
4) Production volume

Because it is difficult for managers to give a deterministic estimate of these attributes in the negotiating phase, they are valued as fuzzy functions, as shown in Fig. 3.
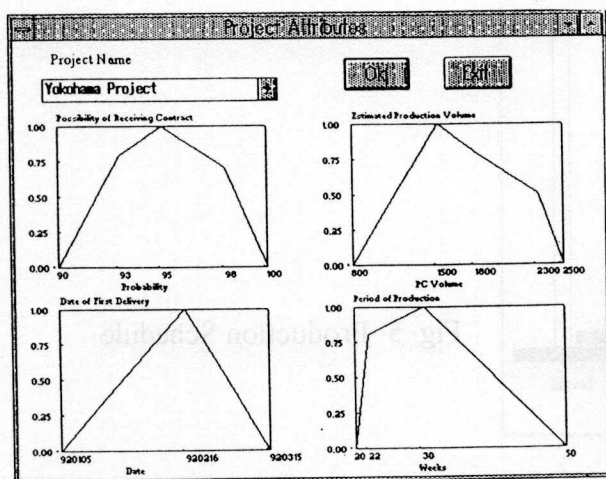

Fig. 3 Fuzzy Functions Describing Project Attributes

The model employs three controllable variables for leveling future production load:
1) Sales division strength
2) Markup
3) Production schedule

Throughout the simulation, these variables were adjusted to level fluctuations in production volume.

5.2 Prototype Simulation System

A prototype system was developed on the MS-Windows platform. The system processes uncertain sales division data such as new project attributes and progress data for ongoing projects. Using this system, managers are able to estimate future production load and adjust controllable variables to stabilize fluctuations in daily production volume, as shown in Fig. 4.
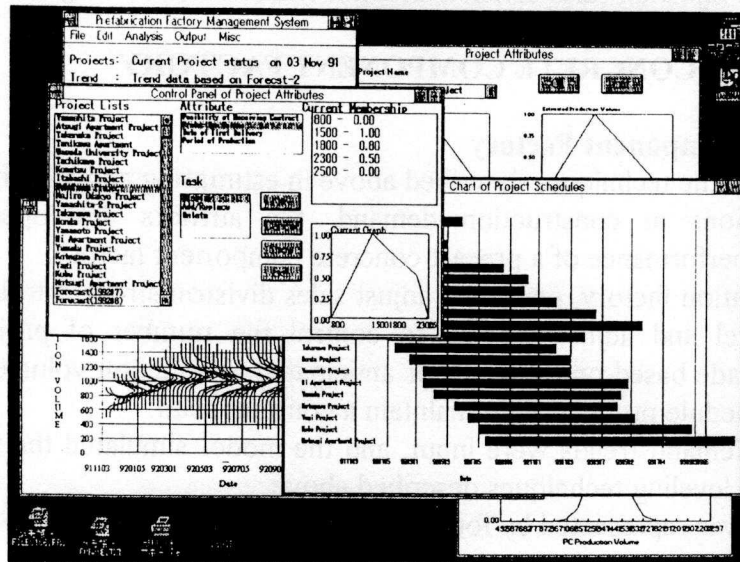

Fig. 4 Windows in
a Prototype System

Hypothetical construction demand data were prepared for the simulation model, which represents the performance of a precast concrete factory. Suppose that the company has eight projects in progress and twelve under negotiation with the production schedule shown in Fig. 5.
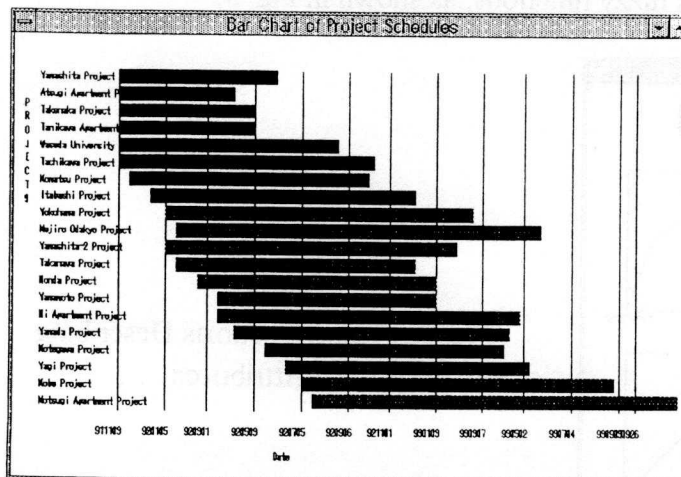

Fig. 5 Production Schedule

5.3 Simulation of Future Production Load

A simulation was run based on the above data. First, production load was estimated. Fig. 6 shows estimated production load based on projects already received. Fig. 7 shows estimated load based on projects under negotiation. Fig. 8 shows the long-term estimated load based on construction demand forecasts.

These three estimates were then combined into a single estimate, shown in Fig. 9, which describes future trends from the following day of operation to the time horizon. With these data, managers can make better decisions for the optimization of daily operations like marketing, contract negotiation, and the scheduling of production.

In the simulation, the authors adjusted sales division strength, markup, and production schedule to stabilize fluctuations in production load from the immediate to long-term future. Fig. 10 shows one of the improved production load estimates. Compared with Fig. 9, the fluctuations in production load have been stabilized substantially.
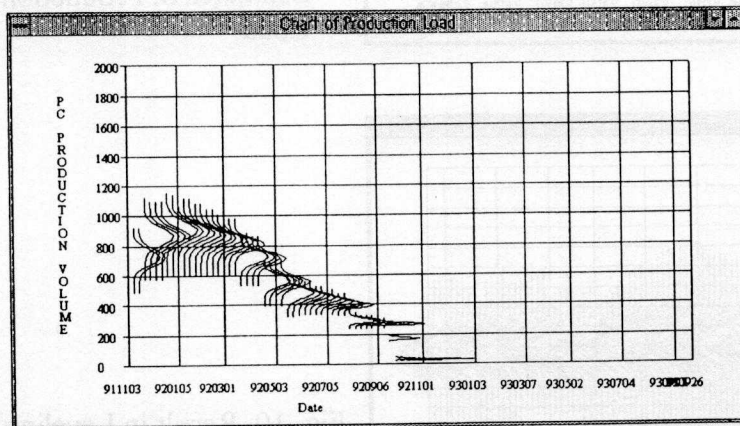

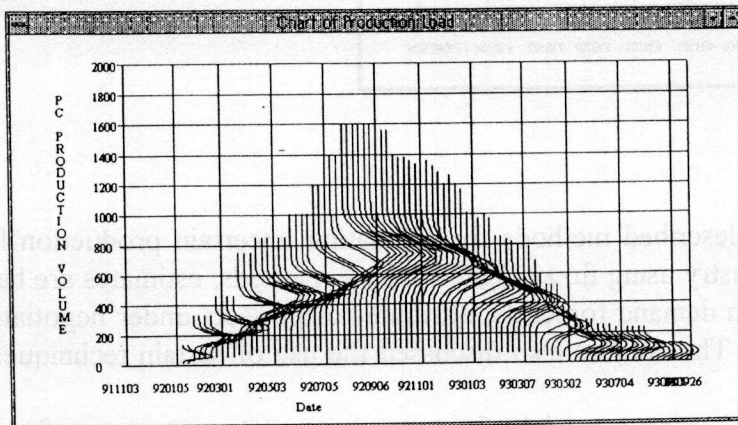Fig. 6 Estimate Based on Projects Received

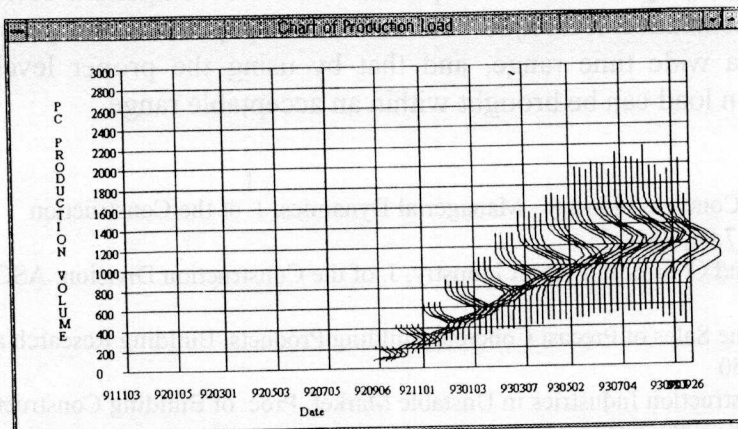Fig. 7 Estimate Based on Projects under Negotiation

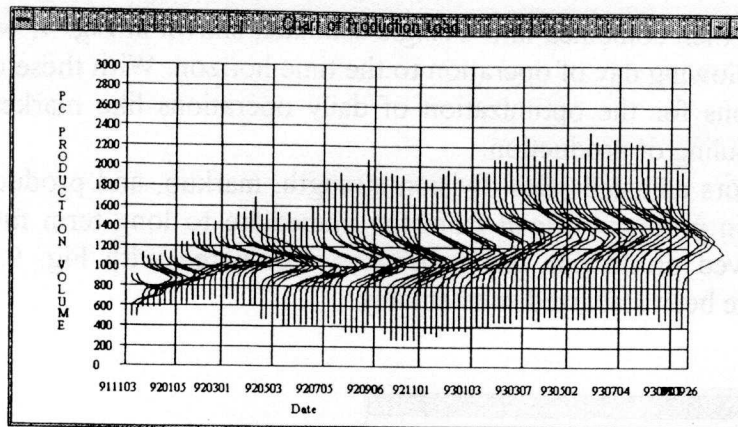Fig. 8 Estimate Based on Construction Demand Forecasts

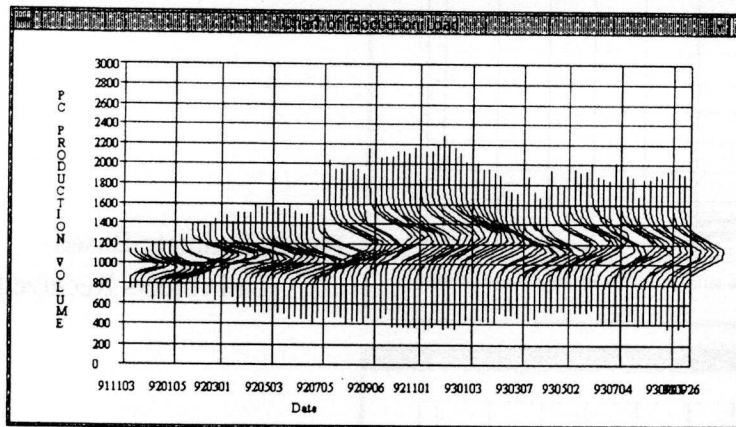Fig. 9 Aggregation of Three Estimates of Production Load

Fig. 10 Result in Leveling of Production Load

6. CONCLUSION

In this paper, the authors described methods for estimating uncertain production load data in the building component industry using fuzzy logic. In these methods, estimates are based on three types of data: construction demand forecasts, attributes of projects under negotiation, and attributes of projects received. The authors also discussed the use of certain techniques to level future production loads.

A simulation was conducted using a model of a precast concrete component factory. The results suggest that use of the estimation technique described in this paper makes it possible to forecast production load over a wide time range, and that by using the proper leveling techniques fluctuations in production load can be brought within an acceptable range.

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