Production Planning Based on DEA Profit Efficiency Models

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ABSTRACT

In this research, the authors propose DEA (data envelopment analysis) profit efficiency models for production planning which is one of important problems in the production and operations management. Different from traditional models, the constraint that the optimal output is supposed to be not less than the original one from the production possibility set is omitted in their developed no output constraint maximum profit (NOCMP) model. Besides, observing that output prices could be varied with the total market demand in the market, the researchers present the no output constraint maximum profit with varied output price (NOCMP-VOP) model. The authors apply these two DEA profit efficiency models to U.S. airline industry for illustration. The developed NOCMP and NOCMP-VOP models in this study contribute to developments of both the DEA profit efficiency model and its applications.

KEYWORDS

Data Envelopment Analysis, DEA, Maximum Profit Model, Output Constraint, Price Variation, Production Planning, Profit Efficiency

INTRODUCTION

Data envelopment analysis (DEA) has been applied as efficiency evaluation and ranking tool in many areas, such as nations’ ranking in the Olympic Games, colleges and universities evaluation, bank industry, production plan and other areas. If products supply or service supply exceeds the market demand in an industry, it will lead to low profit, even loss, the quality of products varies from different levels of corporations, and disorderly competition among the industry. For instance, in 2012, steel industry of China lost 8.249 billion, a 7.39 percent increase year-on-year, due to the excess production capacity. A lot of firms set up in the photovoltaic industry resulted in far diversity among products from distinct firms. Furthermore, in China, overcapacity brought about disorderly competition, low operating efficiency, and other issues in cement, rare earth, shipbuilding industries. In America, at the beginning of this century, internet bubble burst brought about overcapacity to the computer, electronic equipment, and high-tech industries. International financial crisis in 2008 caused overcapacity in many industries. Facing the varied market, if a company does not predict the market demand in next year before setting the production plan, excess production capacity or idle production capacity will lead to a bad performance. The appropriate production plan is the basic step to gain profit.

There are tons of approaches to make production plan. Karlin (1960) developed a dynamic inventory model with linear purchasing cost functions in different conditions, facing various demand

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distributions in diverse stages. They showed monotonicity results with production and inventory capacity limits in the stochastic case. Beckmann (1961) proposed models to find the optimal strategy for adjusting the rate of production to stock under the assumption that production of a product was continuous and subjected to the direct cost of production, with a known demand distribution. Their results revealed the relationship between stock level and the rate of production. Veinott (1964) sought the optimal production levels restricted by the minimizing production and inventory carrying costs, the production, and inventory capacity limits. Veinott (1965) put forward models to analyse multi-periods of equal length of the single product and non-stationary inventory problem, with the optimal stock ordering policy and several classes of product demand independently in each period. Sobel (1970) developed models for optimal production policies of a single product with stochastic demand. Kunreuther and Morton (1973) proposed an algorithm to find all seasonal demand to be met from regular production under the general assumptions for the production and production smoothing, holding the certain cost functions. Their results complemented the findings of Modigliani and Hohn (1955), besides, they provided insight into the nature of the optimal policy for stochastic planning problems.

Kleindorfer and Kunreuther (1978) developed a methodology to show how the forecasting horizons for the stochastic planning problems were related to the planning procedures and the information system within the organization. Appelbaum and Berechman (1991) provided a market equilibrium model, in their model, besides regulatory conditions, supply and demand were also taken into account. Deng and Yano (2006) took price setting and the selection of the quantities of production for certain product within a limited horizon into consideration since the price of product is varied with the total market demand. They defined different characters of the optimal solution in various situations, pondering the types of capacity, motive and inventories. Guilien, Merrett, and Slonim (2014) put forward an intergroup competition scheme (ICS) to solve free riding in team production. They tested their method by a numerical example. The ICS included an internal transfer payment from the lowest to the highest contributing team proportional to the difference in group contributions. (Merrett & Slonim, 2014) Some researchers proposed a management strategy combining the optimal production plan with maintenance strategy and the optimal management strategy of spare parts. They discussed the using features of spare parts and the different carbon footprint, meanwhile, the varied market demand (Kader, Sofiene, Nidhal, & Walid, 2015). Many factors affect the supply and demand of materials and products in a supply chain, which sets obstacles in the way to fulfill the production plan of companies. (Xu, Shang, Wang, & Chiang, 2015). In this case, Xu, et al. (2015) analysed diverse disruption situations and proposed optimal models for the management of production and inventory, confronting with the varied demand and supply in a supply chain. In order to decrease the production cost of the manufacturer, they found the optimal production run time, purchasing time and order quantity. (Xu et al., 2015).

None of the above researchers used DEA to set production plans. Wei, Zhang, and Zhang (2000) put forward an inverse DEA model to estimate the amounts of the optimal inputs and outputs, given certain DEA efficiency level. In the inverse DEA model, they combined the inverse optimization with DEA. The estimation of the amounts of inputs and outputs in DEA model was an inverse optimization problem. Yan, Wei, and Hao (2002) considered preference cone constraints and multi-objective programming on the basis of the inverse DEA model proposed by Wei et al. (2000). Then, Hadi-Vencheh and Foroughi (2006) proposed a generalized DEA model combining multiple objective linear programming to gain the Pareto solution to the amounts of inputs and outputs. Hadi-Vencheh, Foroughi, and Soleimani-damaneh (2008) applied an inverse DEA model to obtain the optimal inputs and outputs when the input and output levels were varied with certain DEA efficiency level. Besides, they developed some especial prerequisites for the estimation of inputs. Lertworasirikul, Charnsathikul, and Fang (2011) proposed an inverse DEA model based on the BCC model to gain a Pareto-efficient solution to the optimal inputs and outputs in a different production possibility set, holding constant DEA efficiency level. Besides, they showed that there existed at least one optimal solution for their DEA model. Some researchers introduced utilizing Pareto, weak Pareto solutions,
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