Mixed-integer linear programming based approach for optimal production planning and inventory control of marine shrimp farming supply chain network

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Abstract

Marine shrimp farming is an aquaculture business for the cultivation of marine shrimp or prawns for human consumption. Giant freshwater prawn farming is one of the most popular marine shrimp farming in Thailand: 90% of the prawn yield is for domestic consumption and the remaining is for export. Although the giant freshwater prawn farming has been developed during more than a century, the main farming operations are still traditional. These farming operations can be improved by applying modern farming techniques. This paper was motivated by a real problem in a large giant freshwater prawn farm located in the Western region of Thailand, which manages the whole prawn farming supply chain network. In this problem, the farmer tackles when and where prawns are to be cultured and harvested, and how the prawns are to be transported and stored at distribution centres, in order to maximize the supply chain profit. Because prawns are perishable products, the farmer cannot store the large amount of prawn at distribution centres for a long time. Therefore, the farmer needs an effective tool for production planning and inventory control, which maintains the quality (freshness) of the prawn under the constraint of supply resources capacities. Operations research (OR) models are designed to optimize a specific objective criterion subject to set of constraints. Recently, many studies on OR models were applied to agriculture food supply chain management. This paper extends our previous mixed-integer linear programming (MILP) for the prawn firming supply chain network by adding production planning and inventory control functions to consider the freshness of prawn. The farmer is concerned about the timing of cultivating and harvesting, the number of hiring labors, the volume of harvesting, the storage at distribution centres and selection of transportation methods, to achieve high freshness of delivered prawn. The production planning is applied to assist cultivating and harvesting scheduling under consideration of labor hiring, dispatching capacity and time limitation. The inventory controlling manages the volume of prawn stored at distribution centres such that the stored period is at most one week. As a result, the new model can maximize the farmer's profit while improving the freshness of prawn. The numerical results show that the proposed model holds a potential to increase the total profit surplus by 4.71% when compared with farmer's solution. The model can also be used to investigate the relationship between the revenue, total costs and timing of operations, i.e., purchasing, cultivating, harvesting, storing and dispatching. Thus, the model

becomes a valuable tool for the farmer to plan future resource requirements and production capacity as well as to identify potential bottlenecks in the supply chain network and to demonstrate the feasibility of smart marine shrimp farming assisted by OR techniques.

Keywords mixed-integer linear programming, supply chain network, giant freshwater prawn, production planning, inventory control