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# Multi-objective optimization for delivering perishable products with mixed time windows

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**ABSTRACT**

Perishable products generally have a short shelf life, and the freshness often depends on the postharvest time. The freshness of perishable products can ensure better customer satisfaction. Owing to the deterioration of perishable goods, the complexity of the corresponding vehicle routing problem (VRP) increases, because time delay will lead to serious costs. In this study, we are concerned with not only time-sensitive spoilage rates with mixed time windows, but also the delay costs in delivering perishable products. This study proposes a multi-objective VRP optimization model with mixed time windows and perishability (MO-VRPMTW-P) to minimize the distribution costs and maximize the freshness of perishable products. Then, in view of the fresh products orders space and time characteristics, we propose a heuristic algorithm (ST-VNSGA) composed of a variable neighbourhood search (VNS) method and a genetic algorithm (GA) considering the spatio-temporal (ST) distance to solve the complex multi-objective problem. The solution algorithms are evaluated through a series of experiments. We illustrate the performance and efficiency comparisons of ST-VNSGA with the method without spatio-temporal strategy algorithm and NSGA-II algorithm. It is demonstrated that the proposed ST-VNSGA algorithm can lead to a substantial decrease in the computation time and major improvements in solutions quality, thus revealing the efficiency of considering the spatio-temporal strategy with mixed time windows.



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# Večkriterijska optimizacija za dostavo pokvarljivih izdelkov z mešanimi časovnimi okni

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**POVZETEK**

Pokvarljivi izdelki imajo na splošno kratek rok trajanja, njihova svežina pa je pogosto odvisna od časovnega obdobja od žetve. Svežina pokvarljivih izdelkov lahko zagotovi večje zadovoljstvo strank. Z upoštevanjem poslabšanja kakovosti pokvarljivega blaga se poveča kompleksnost problema usmerjanja dostavnega vozila (VRP), saj časovna zamuda povzroči resne stroške. Študija se ne ukvarja le s časovno občutljivimi stopnjami kvarjenja izdelkov z mešanimi časovnimi okni, temveč tudi s stroškom zamude pri dobavi pokvarljivih izdelkov. Študija predlaga večkriterijski optimizacijski model z mešanimi časovnimi okni in pokvarljivostjo (MO-VRPMTW-P) za zmanjšanje stroškov distribucije in zvečanje svežine pokvarljivih izdelkov. Glede na prostorsko razporeditev naročil svežih izdelkov in časovne značilnosti predlagamo hevristični algoritem (ST-VNSGA), sestavljen iz algoritma za preiskovanje s spremenljivo soseščino (VNS), genetskega algoritma (GA) in prostorsko-časovne (ST) razdalje za reševanje večkriterijskega optimizacijskega problema. Primerjani algoritmi so bili ovrednoteni s poskusi. V raziskavi je prikazana uspešnost in učinkovitost ST-VNSGA v primerjavi z algoritmom brez prostorsko-časovne strategije in algoritmom NSGA-II. Izkazalo se je, da lahko predlagani algoritem ST-VNSGA znatno zmanjša potreben računski čas in bistveno izboljša kakovost rešitev, kar opravičuje upoštevanje prostorsko-časovne strategije pri reševanju problemov z mešanimi časovnimi okni.



**PODATKI O ČLANKU**

*Ključne besede:*
Distribucija pokvarljivih izdelkov;
Večkriterijske optimizacije;
Mešana časovna okna;
Svežina;
Hevristični algoritmi;
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