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Short communication

An optimal solution to a three echelon supply chain network with multi-product and multi-period

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ABSTRACT

Recently, Kadadevaramath et al. (2012) [1] presented a mathematical model for optimizing a three echelon supply chain network. Their model is an integer linear programming (ILP) model. In order to solve it, they developed five algorithms; four of them are based on a particle swarm optimization (PSO) method and the other is a genetic algorithm (GA). In this paper, we develop a more general mathematical model that contains the model developed by Kadadevaramath et al. (2012) [1]. Furthermore, we show that all instances proved in Kadadevaramath et al. (2012) [1] can easily be solved optimally by any integer linear programming solver.

1. Introduction

The highly competitive business environments of today force companies choose good decisions in order to survive. One of these critical decisions may involve integrating the supply chain in which the companies participate to enable the ability to make business decisions jointly. A supply chain network (SCN) is typically comprised of suppliers, producers, distributors and retailers. It is important to note that independent decisions benefit only one party of the SCN. On the other hand, aligned decisions benefit all parties and the gains are higher when compared with the gains obtained by using independent decisions (see for example [2–5]). Therefore, the success of a company depends basically on its ability to align all SCN parties seamlessly. A SCN could contain many stages and several members in each stage thus making it difficult to manage its whole integration. Therefore, it is easier to consider a three stage SCN. Although there are several research papers that have studied three-stage SCN models, these are limited in several ways. Actually, a few papers exist in the literature that have dealt with lot sizing for multiple products and multi-players in a three-level SCN (see for instance [6–8]). Based on that, Kadadevaramath et al. [1] presented a mathematical model for a three echelon SCN with multiple players in each stage. Given that it was not possible to derive closed form expressions to solve the integer linear programming model proposed by Kadadevaramath et al. [1], near optimal solutions were sought with the application of methodologies based on four particle swarm optimization (PSO) algorithms (B-PSO, LDIW-PSO, CFM-PSO, NLIWD-PSO) and one genetic algorithm (GA).

The PSO method was first introduced by Kennedy and Eberhart [9] in 1995. Several examples exist in the literature that show that PSO is an efficient method to search for better solutions for hard problems. However, as it is typical with all the evolutionary algorithms, the PSO does not guarantee to get an optimal solution for a problem. Therefore, it is a good option for problems where obtaining an optimal solution is very difficult. Additionally, PSO and GA techniques require more computational time than other common techniques (for instance see [10,11]).

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Table 1
Optimal solutions to the 20 instances.

Instance	X_{11111}	X_{11121}	X_{11311}	X_{11321}	X_{12111}	X_{12121}	X_{12211}	X_{13111}	X_{13211}	X_{13311}	X_{13321}	Y_{1111}	Y_{1121}	Y_{1131}	Y_{1141}	Y_{1151}	Y_{1161}	Y_{1231}	Y_{1241}
1	100	72	300	0	78	72	322	112	150	138	72	83	98	40	0	89	90	15	57
2	186	0	214	86	64	86	336	126	150	124	86	96	61	55	0	92	96	5	81
3	100	65	300	0	85	65	315	105	150	145	65	88	70	0	71	76	95	54	11
4	153	0	247	53	97	53	303	93	150	157	53	68	60	42	93	55	82	53	0
5	142	0	258	42	108	42	292	82	150	168	42	64	79	21	98	56	82	42	0
6	100	53	300	0	97	53	303	93	150	157	53	61	95	3	89	75	77	53	0
7	170	0	230	70	80	70	320	110	150	140	70	82	89	90	1	56	82	0	70
8	129	0	271	29	121	29	279	69	150	181	29	62	74	63	30	98	73	0	29
9	138	0	262	38	112	38	288	78	150	172	38	73	86	65	40	78	58	0	38
10	100	19	300	0	131	19	269	59	150	191	19	81	76	69	47	69	58	0	19
11	123	0	277	23	127	23	273	63	150	187	23	86	58	93	30	61	72	0	23
12	100	38	300	0	112	38	288	78	150	172	38	96	95	67	13	74	55	0	38
13	100	72	300	0	78	72	322	112	150	138	72	91	76	69	0	91	73	3	69
14	130	0	270	30	120	30	280	70	150	180	30	90	64	24	89	79	54	30	0
15	165	0	235	65	85	65	315	105	150	145	65	80	72	61	20	71	96	0	65
16	100	0	300	0	150	0	250	40	150	210	0	91	66	64	69	54	56	0	0
17	100	7	300	0	143	7	257	47	150	203	7	72	85	46	77	57	63	7	0
18	100	0	300	0	150	0	250	40	150	210	0	60	100	68	58	62	52	0	0
19	92	0	300	0	150	0	242	32	150	210	0	82	67	58	56	72	57	0	0
20	155	0	245	55	95	55	305	95	150	155	55	81	81	95	8	81	54	0	55