*Review Article*

# Reviewing the Literature of Inventory Models under Trade Credit Contact

## Zohreh Molamohamadi, Napsiah Ismail, Zulkiflle Leman, and Norzima Zulkifli

*Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43300 Selangor, Malaysia*

Correspondence should be addressed to Zohreh Molamohamadi; zmmohamadi@gmail.com

In the classical inventory models, it was assumed that the buyer pays for the purchased items as they are received from the seller. In practice, however, the seller allows the buyer to settle the account with a delay period. Such a contract has attracted the attention of many researchers and practitioners in recent years. Thus, this paper addresses the researches with delay in payment and presents pertinent information about developments and extensions of such models to provide an up-to-date review of the studies conducted since 1973 and assist in developing the future researches.

## 1. Introduction

In conventional business transactions, it was implicitly assumed that the retailers must pay for the procured items as soon as they are received. However, in today's intensely competitive market, such an assumption would no longer be practical. Delayed payment is now an invaluable promotional tool for the suppliers to increase profit through stimulating more sales and a unique opportunity for the retailers to reduce demand uncertainty and its associated risks. In other words, when the supplier sends the ordered units to the retailer without being paid, he actually transfers the storage responsibility and costs to the retailers, while bearing the demand uncertainty risk.

Although permissible delay in payment has been extensively studied during recent years, there are still great research gaps in this area, convenient for future studies. The focus of this research is therefore reviewing and classifying the related literature to identify appropriate areas for extension.

It is necessary to clarify the first mentioned feature (delay in payment). Different types of delay in payment can be extracted from the literature. Piasecki [1] and Molamohamadi et al. [2] classified these types under consignment inventory (CI) contract into four groups;

*(I) Pay as Sold/Used.* In this type of contract which is shown in Figure 1 the buyer must pay for the received goods from the vendor as soon as he uses or sells them to his own customers.

*(II) Pay as Sold/Used during a Predefined Period.* This is an agreement where the vendor and buyer agree upon a predetermined period, so-called credit period, during which the buyer pays to the vendor at the time of selling or using the items. Based on the vendor and buyer contract, at the end of this period, the latter must pay either for the remaining items in inventory, return them to the vendor, or pay for the interest charged (Figure 2).

*(III) Pay after a Predefined Period.* As it is depicted in Figure 3, the buyer is permitted here to postpone the payment until the end of credit period and earn interest during this period. However, after this period, interest will be charged for the items in stock, often with a greater rate than the earned interest.

*(IV) Pay for the Prior Order at the Time of Establishing the New Replenishment.* In this type of CI, called order to order consignment by Piasecki [1], whenever the buyer places an order, he pays the previous order cost to the vendor (Figure 4).
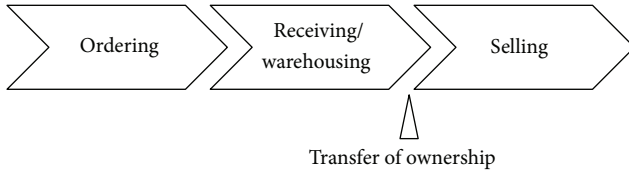
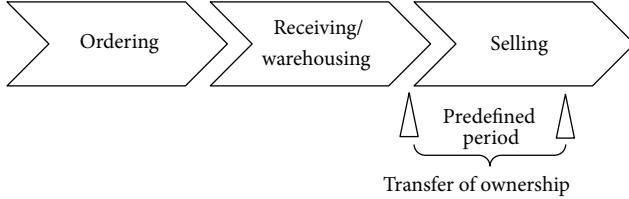FIGURE 1: Transfer of ownership in the first type of delay in payment.



FIGURE 2: Transfer of ownership in the second type of delay in payment.
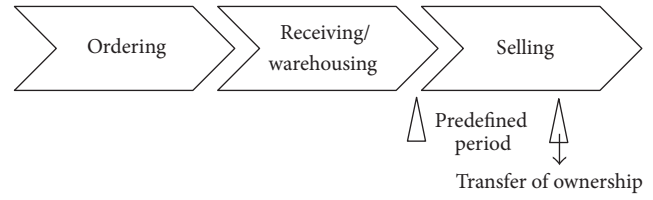


FIGURE 3: Transfer of ownership in the third type of delay in payment.

The rest of this paper is organized as follows. Section 2 discusses the models that have not considered any of the six factors (A to F). Section 3 focuses on the papers with one of the factors and Sections 4 and 5 represent the models with two and more combinations of the aforementioned factors, respectively. A conclusion of the paper is provided in Section 6.

## 2. The Basic Models

Trade credit was first discussed by Haley and Higgins [5] who examined the effect of a two-part trade credit policy with a cash discount on the optimal inventory policy and payment time. Two-part trade credit refers to the case that the supplier considers cash discount for paying within a specified period and due in a larger credit period. Later, Chapman et al. [6] obtained the optimal replenishment policies under different considerations such as traditional EOQ model, paying when the items are sold during a credit period, and paying after a fixed period. Goyal [7] assumed that the supplier allows the retailer a predefined period to settle the account and presented mathematical models for determining the economic order quantity. His paper is the base for many papers published thereafter.

Dave [9] reformulated Goyal's [7] model by considering different selling and purchasing prices. However, this suggestion did not receive the proceeding researches' attention for about two decades. Chung [16] simplified the solution procedure proposed in Goyal [7] by presenting a simple procedure to determine the optimal time interval between successive orders. Teng [24] modified Goyal [7]'s model by differentiating between the unit purchase cost and selling price and concluded that some retailers may order less quantity and benefit from the permissible delay more frequently. Ouyang et al. [25] generalized Goyal's [7] model by assuming two-part trade credit. Considering equal interest earned and charged, Abad and Jaggi [27] developed a model of seller-buyer relationship under cooperative and noncooperative structures with price-dependent demand to find the optimal policies of the seller (selling price and credit period) and the buyer (unit price and replenishment cycle). Besides assuming not necessarily equal selling and purchasing costs, Chung and Huang [28] extended Goyal's [7] model by assuming that the retailer pays a partial amount of total purchasing cost at the end of the credit period and the remaining balance would be paid by loan from the bank. Chung and Huang [29] relaxed Goyal's [7] assumption of the infinite replenishment

The purpose of this paper is reviewing the literature for inventory models with the second and the third types of delay in payment, mainly known as trade credit, and illustrating the limitations of the previous studies as well as the potential areas for extending this field of science (for the other types of CI, please refer to Molamohamadi et al. [2]).

In 2008, Chang et al. [3] reviewed the trade credit literature in a table and then classified and discussed their extensions and weaknesses based on shortage, deterioration, order-quantity dependent, and inflation. Moreover, Soni et al. [4] presented a review of the inventory models with trade credit agreement and classified the papers into some categories, such as economic order quantity (EOQ) model, deterioration, discounted cash flows (DCF), and stochastic demand and discussed their principal features. DCF approach is taking the time value of money, that is, inflation, into account. With the same framework virtually, this paper groups the researches under trade credit contract into six categories based on the most important features of their modeling: (1) allowable shortage, (2) deterioration rate, (3) two-level trade credit, (4) link to order quantity, (5) limited storage space, and (6) inflation. Accordingly, we characterize the previous trade credit researches by using the aforementioned categories and some other major assumptions as demonstrated in Table 1. Then, the papers are grouped based on whether they have considered none, one, two, or more of these six factors and are reviewed in detail.

The following electronic databases are adopted in the paper: (1) Science Direct, (2) IEEE, (3) Springer Link, (4) Taylor and Francis, (5) JSTOR, (6) Ebscohost, (7) Hindawi, and (8) Proquest. The discussed journals in this paper include *Applied Mathematical Modelling*, *Applied Mathematics and Computation*, *Computers & Industrial Engineering*, *Computers & Operations Research*, *European Journal of Operational Research*, *Expert Systems with Applications*, *International Journal of Production Economics*, *Journal of the Operational Research Society*, and *Discrete Dynamics in Nature and Society*.
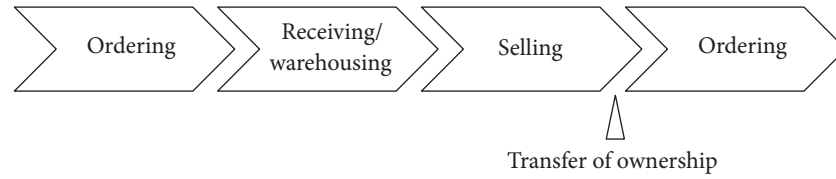
FIGURE 4: Transfer of ownership in the fourth type of delay in payment.

rate by applying an economic production quantity (EPQ) model. Unlike EOQ model, in an EPQ model, the units would be replenished at a finite rate. In a different point of view from Ouyang et al. [25], Huang and Chung [32] extended Goyal's [7] model to the case of two-part trade credit. Huang [38] incorporated the payment rule discussed in Chung and Huang [28] and the two-part trade credit assumed in Huang and Chung [32] to develop the buyer's EOQ inventory system. Another general framework of Goyal's [7] EOQ model is proposed in Huang [39], where not only selling and purchasing prices have been differentiated, but also the retailer is offered partial trade credit. In partial trade credit, the retailer makes a partial payment to the supplier when he receives the order and delays paying the remaining balance till the end of the credit period. Chung and Huang [45] extended Goyal [7]'s model as well by developing an EOQ model when a percentage of defective items is considered.

Under two credit periods with progressive interest charges offered by a bank, Goyal et al. [54] formulated the retailer's EOQ model and obtained the closed-form optimal solution. They assumed that paying before the first defined period would cause no interest charge, while paying after the second predetermined period would result in larger interest on the unpaid balance in comparison to paying off between the first and the second delay periods. Huang et al. [57] established an EPQ model under cash discount and delay in payment with different selling and purchasing costs to incorporate Teng [24], Chung and Huang [29], and Huang and Chung [32]. Soni and Shah [58] dealt with the problem of determining a retailer's optimal ordering policies when demand is stock-dependent and progressive credit periods are offered by the supplier. Sana and Chaudhuri [59] established an EOQ model under different types of deterministic demand, including constant, time-dependent, stock-dependent, price-dependent, and both price and stock-dependent demands. They assumed that the supplier offers the retailer some credit periods with different rates of price discount. Y.-F. Huang and H.-F. Huang [61] developed an EPQ model under trade credit contract and generalized Chung and Huang's [29] proposed model by considering higher selling price than purchasing cost. Ho et al. [64] represented an integrated supplier-buyer inventory model under price-sensitive demand and two-part permissible delay in payment to generalize Abad and Jaggi [27]. Teng and Goyal [80] complemented the shortcoming of Y.-F. Huang and H.-F. Huang [61] in calculating the interest charged and relaxed the limitation of the relationship between the earned and charged interest. They also proposed a method for finding the global optimal solution explicitly without taking compli-

cated differential calculus. Including fixed credit period and imperfect quality items, Chen and Kang [83] developed an integrated model for a supply chain, consisting of a vendor and a buyer, and obtained the optimal values for the buyer's quantity of order as well as vendor's production frequency. Besides indicating the shortcomings of the proofs presented by Y.-F. Huang and H.-F. Huang [61], Chung [86] corrected and generalized their proofs by applying analytic approach.

Incorporating logistic risk in the trade credit context, Tsao [102] formulated an EPQ model from risk-neutral and risk-averse perspectives and determined the retailer's optimal replenishment decisions when there are supply chain uncertainties due to the disruption or defective items. Sarkar [115] developed an inventory system with finite replenishment rate, stock-dependent demand, and the production of defective items which follows Weibull distribution. They assumed a payment scheme having two progressive delay periods with different interest rates. When the demand is a linear increasing function of time, Teng et al. [116] determined the optimal order quantity and cycle time in an EOQ framework with permissible delay in payment. Cheng et al. [117] formulated EOQ model under trade credit approach and different financial policies. They assumed that the interest earned is not inevitably smaller than the interest charged and found, the optimal values for retailer's payoff time, cycle time, and order quantity. Zhong and Zhou [124] obtained optimal ordering and trade credit policy in a two-echelon supply chain model with deterministic demand. They assumed that the retailer is proposed one-part or two-part delay in payment contract. Under one-part contract, the retailer must pay off within a prespecified period, while, in the latter, as mentioned earlier, he can choose between paying the discounted cost in a shorter period or the full payment at the end of the net credit period. Chern et al. [137] presented the EOQ model for a vendor and a buyer under trade credit agreement with credit-dependent demand. Having considered the vendor as the leader, they applied noncooperative Stackelberg equilibrium to find the optimal solution.

Besides Chung [86], Huang et al. [145] developed another proof for Y.-F. Huang and H.-F. Huang [61]. Shah et al. [148] developed an integrated inventory model with trapezoidal price-sensitive demand with two-part trade credit. Under permissible delay in payment and time-sensitive demand, Janková et al. [154] determined the retailer's optimal price and replenishment interval. They demonstrated theoretical results by an illustrative example and specific graphical results. Moussawi-Haidar et al. [162] developed a three-echelon supply chain model, including a supplier, a retailer, and a bank, where the retailer is offered a credit period by the

TABLE 1: Summary of related literature for trade credits.

| Author | Model | Demand type | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| Haley and Higgins [5] | EOQ | Constant | — | — | — | — | — | — |
| Chapman et al. [6] | EOQ | Constant | — | — | — | — | — | — |
| Goyal [7] | EOQ | Constant | — | — | — | — | — | — |
| Ventura [8] | EOQ | Constant | — | — | ✓ | — | — | — |
| Dave [9] | EOQ | Constant | — | — | — | — | — | — |
| Chung [10] | EOQ | Constant | — | — | — | — | — | ✓ |
| Jaggi and Aggarwal [11] | EOQ | Constant | — | ✓ | — | — | — | ✓ |
| Aggarwal and Jaggi [12] | EOQ | Constant | — | ✓ | — | — | — | — |
| Khouja and Mehrez [13] | EOQ | Constant | — | — | — | ✓ | — | — |
| Hwang and Shinn [14] | EOQ | Price dependent | — | ✓ | — | — | — | — |
| Jamal et al. [15] | EOQ | Constant | ✓ | ✓ | — | — | — | — |
| Chung [16] | EOQ | Constant | — | — | — | — | — | — |
| Chu et al. [17] | EOQ | Constant | — | ✓ | — | — | — | — |
| Sarker et al. [18] | EOQ | Constant | ✓ | ✓ | — | — | — | ✓ |
| Liao et al. [19] | EOQ | Stock dependent | — | ✓ | — | — | — | ✓ |
| Jamal et al. [20] | EOQ | Constant | — | ✓ | — | — | — | — |
| Chang and Dye [21] | EOQ | Constant | ✓ | ✓ | — | — | — | — |
| Chung et al. [22] | EOQ | Constant | — | ✓ | — | — | — | — |
| Chang et al. [23] | EOQ | Constant | — | ✓ | — | — | — | — |
| Teng [24] | EOQ | Constant | — | — | — | — | — | — |
| Ouyang et al.  [25] | EOQ | Constant | — | — | — | — | — | — |
| Shinn and Hwang [26] | EOQ | Price dependent | — | — | — | ✓ | — | — |
| Abad and Jaggi [27] | Noncooperative and cooperative | Price dependent | — | — | — | — | — | — |
| Chung and Huang [28] | EOQ | Constant | — | — | — | — | — | — |
| Chung and Huang [29] | EPQ | Constant | — | — | — | — | — | — |
| Huang [30] | EOQ | Constant | — | — | ✓ | — | — | — |
| Chang et al. [31] | EOQ | Time dependent | — | ✓ | — | ✓ | — | — |
| Huang and Chung [32] | EOQ | Constant | — | — | — | — | — | — |
| Chung and Liao [33] | EOQ | Constant | — | ✓ | — | ✓ | — | — |
| Chang and Teng [34] | EOQ | Constant | — | ✓ | — | — | — | — |
| Chung et al. [35] | EOQ | Constant | — | — | — | ✓ | — | — |
| Ouyang et al. [36] | EOQ | Constant | — | ✓ | — | — | — | — |
| Teng et al. [37] | EOQ | Price dependent | — | ✓ | — | — | — | — |
| Huang [38] | EOQ | Constant | — | — | — | — | — | — |
| Huang [39] | EOQ | Constant | — | — | — | — | — | — |
| Teng [40] | EOQ | Constant | — | — | — | — | — | ✓ |
| Ouyang et al. [41] | EOQ | Constant | ✓ | ✓ | — | — | — | — |
| Chung and Liao [42] | EOQ | Constant | — | ✓ | — | ✓ | — | ✓ |
| Huang [43] | EOQ | Constant | — | — | ✓ | — | ✓ | — |
| Chung and Huang [44] | EOQ | Constant | — | ✓ | — | — | ✓ | — |
| Chung and Huang [45] | EOQ | Constant | — | — | — | — | — | — |
| Wu et al. [46] | EOQ | Stock dependent | ✓ | ✓ | — | — | — | — |
| Teng et al. [47] | EPQ | Price dependent | — | — | ✓ | — | — | — |
| Chen and Ouyang [48] | EOQ | Constant | ✓ | ✓ | — | — | — | — |
| Ouyang et al. [49] | EOQ | Constant | — | ✓ | — | — | — | — |
| Huang [50] | EOQ | Constant | — | — | — | ✓ | — | — |
| Huang [51] | EPQ | Constant | — | — | ✓ | — | — | — |
| Teng et al. [52] | EOQ | Constant | — | — | ✓ | — | — | — |
| Chung and Huang [53] | EOQ | Constant | — | ✓ | ✓ | — | ✓ | — |

TABLE 1: Continued.

| Author | Model | Demand type | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| Goyal et al. [54] | EOQ | Constant | — | — | — | — | — | — |
| Teng and Goyal [55] | EOQ | Constant | — | — | ✓ | — | — | — |
| Su et al. [56] | Integrated | Credit dependent | — | — | ✓ | — | — | — |
| Huang et al. [57] | EPQ | Constant | — | — | — | — | — | — |
| Soni and Shah [58] | EOQ | Stock dependent | — | — | — | — | — | — |
| Sana and Chaudhuri [59] | EOQ | Different types* | — | — | — | — | — | — |
| Hsu et al. [60] | EOQ | Constant | — | — | — | ✓ | — | — |
| Y.-F. Huang and H.-F. Huang [61] | EPQ | Constant | — | — | — | — | — | — |
| Huang and Hsu [62] | EOQ | Constant | — | — | ✓ | — | — | — |
| Liao [63] | EPQ | Constant | — | ✓ | ✓ | — | — | — |
| Ho et al. [64] | Integrated | Price dependent | — | — | — | — | — | — |
| Huang and Liao [65] | EOQ | Constant | — | ✓ | — | — | — | — |
| Jaggi et al. [66] | EOQ | Credit dependent | — | — | ✓ | — | — | — |
| Tsao and Sheen [67] | EOQ | Price and time dependent | — | ✓ | — | — | — | — |
| Thangam and Uthayakumar [68] | EPQ | Constant | — | — | ✓ | — | — | — |
| Tsao [69] | EOQ | Constant | — | — | ✓ | — | — | — |
| Chung [70] | EOQ | Constant | — | ✓ | — | — | — | — |
| De and Goswami [71] | EOQ | Probabilistic | — | ✓ | ✓ | — | — | — |
| Ouyang et al. [72] | EOQ | Constant | — | ✓ | — | ✓ | — | — |
| Chung and Huang [73] | EOQ | Constant | ✓ | — | — | — | — | — |
| Teng [74] | EOQ | Constant | — | — | ✓ | — | — | — |
| Teng and Chang [75] | EPQ | Constant | — | — | ✓ | — | — | — |
| Chang et al. [76] | Integrated | Price dependent | — | — | — | ✓ | — | — |
| Chung and Liao [77] | EOQ | Constant | — | — | — | ✓ | — | ✓ |
| Thangam and Uthayakumar [78] | EPQ | Price and credit dependent | — | ✓ | ✓ | — | — | — |
| Ouyang et al. [79] | Integrated | Price dependent | — | — | — | ✓ | — | — |
| Teng and Goyal [80] | EPQ | Constant | — | — | — | — | — | — |
| Teng et al. [81] | EOQ | Constant | — | — | ✓ | — | ✓ | — |
| Yang [82] | EOQ | Constant | — | ✓ | — | ✓ | — | ✓ |
| Chen and Kang [83] | Integrated | Constant | — | — | — | — | — | — |
| Chang et al. [84] | EOQ | Stock dependent | ✓ | ✓ | — | — | ✓ | — |
| Ouyang et al. [85] | EOQ | Constant | — | — | — | ✓ | — | — |
| Chung [86] | EPQ | Constant | — | — | — | — | — | — |
| Liao and Huang [87] | EOQ | Constant | — | ✓ | ✓ | — | — | ✓ |
| Zhang et al. [88] | Noncooperative | Price dependent | — | — | ✓ | — | — | — |
| Kreng and Tan [89] | EOQ | Constant | — | — | ✓ | ✓ | — | — |
| Thangam and Uthayakumar [90] | EOQ | Price dependent | — | ✓ | ✓ | — | ✓ | — |
| Chang et al. [91] | EOQ | Constant | — | ✓ | — | ✓ | — | ✓ |
| Hu and Liu [92] | EPQ | Constant | ✓ | — | — | — | — | — |
| Min et al. [93] | EOQ | Stock dependent | — | ✓ | ✓ | — | — | — |
| Chang et al. [94] | EPQ | Constant | — | ✓ | ✓ | — | — | — |
| Feng et al. [95] | EOQ | Constant | — | — | ✓ | — | — | — |
| Jaggi and Verma [96] | EOQ | Constant | — | — | ✓ | — | — | — |
| Dye and Ouyang [97] | EOQ | Time dependent | — | ✓ | ✓ | — | — | — |
| Ho [98] | Integrated | Price and credit linked Demand | — | — | ✓ | — | — | — |
| Roy and Samanta [99] | EPQ | Constant | — | ✓ | — | — | — | — |
| Liang and Zhou [100] | EOQ | Constant | — | ✓ | — | — | ✓ | — |
| Chung [101] | EOQ | Constant | — | ✓ | — | — | — | — |
| Tsao [102] | EPQ | Constant | — | — | — | — | — | — |

TABLE 1: Continued.

| Author | Model | Demand type | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| Chung and Lin [103] | EOQ | Constant | — | ✓ | — | — | — | ✓ |
| Kreng and Tan [104] | EPQ | Constant | — | — | ✓ | — | — | — |
| Balkhi [105] | EOQ | Time dependent | — | ✓ | — | — | — | ✓ |
| Khanra et al. [106] | EOQ | Time dependent | — | ✓ | — | — | — | — |
| Teng et al. [107] | EOQ | Stock dependent | — | ✓ | — | — | ✓ | — |
| Teng et al. [108] | Integrated and noncooperative | Constant | — | — | — | ✓ | — | — |
| Mahata [109] | EPQ | Constant | — | ✓ | ✓ | — | — | — |
| Arkan and Hejazi [110] | Integrated and noncooperative | Normal distribution | ✓ | — | — | — | — | — |
| Musa and Sani [111] | EOQ | Constant | — | ✓ | — | — | — | — |
| Lin et al. [112] | Integrated | Credit dependent | — | — | ✓ | — | — | — |
| Chung [113] | EPQ | Constant | — | — | ✓ | — | ✓ | — |
| Liao et al. [114] | EOQ | Constant | — | ✓ | — | ✓ | ✓ | — |
| Sarkar [115] | EPQ | Stock dependent | — | — | — | — | — | — |
| Teng et al. [116] | EOQ | Time dependent | — | — | — | — | — | — |
| Cheng et al. [117] | EOQ | Constant | — | — | — | — | — | — |
| Teng and Lou [118] | EOQ | Credit dependent | — | — | ✓ | — | — | — |
| Dye [119] | EOQ | Price and time dependent | ✓ | ✓ | ✓ | — | — | — |
| Chung [120] | Integrated | Credit dependent | — | — | ✓ | — | — | — |
| Su [121] | integrated | Constant | ✓ | — | — | — | — | — |
| Thangam [122] | EOQ | Constant | — | ✓ | ✓ | — | — | — |
| Soni and Patel [123] | Integrated | Price dependent | — | — | ✓ | — | — | — |
| Zhong and Zhou [124] | Noncooperative | Constant | — | — | — | — | — | — |
| Shah et al. [125] | Integrated | Time and price dependent | — | — | — | ✓ | — | — |
| Guchhait et al. [126] | EOQ | Stock and price dependent | — | ✓ | — | ✓ | ✓ | — |
| Chung [127] | EOQ | Constant | — | — | — | ✓ | — | — |
| Das et al. [128] | Integrated | Constant | — | ✓ | — | — | — | — |
| Liao et al. [129] | EOQ | Constant | — | ✓ | — | — | — | — |
| Yang and Chang [130] | EOQ | Constant | ✓ | ✓ | — | — | ✓ | ✓ |
| Feng et al. [131] | EPQ | Constant | — | — | ✓ | — | — | — |
| Giri and Maiti [132] | Integrated | Price and credit dependent | — | — | ✓ | — | — | — |
| Soni [133] | EOQ | Stock dependent | — | ✓ | ✓ | — | ✓ | — |
| Taleizadeh et al. [134] | EOQ | Constant | ✓ | — | — | — | — | — |
| Yu [135] | Integrated | Price dependent | ✓ | ✓ | — | — | — | — |
| Zhong and Zhou [136] | Integrated and noncooperative | Stock dependent | — | — | — | — | ✓ | — |
| Chern et al. [137] | Noncooperative | Credit dependent | — | — | — | — | — | — |
| Ouyang and Chang [138] | EPQ | Constant | ✓ | — | — | — | — | — |
| Annadurai and Uthayakumar [139] | EOQ | Credit dependent | ✓ | ✓ | ✓ | — | — | — |
| Teng et al. [140] | EOQ | Time dependent | — | — | ✓ | ✓ | — | — |
| Khanra et al. [141] | EOQ | Time dependent | ✓ | — | — | — | — | — |
| Hou and Lin [142] | EOQ | Price and time dependent | — | ✓ | — | — | — | ✓ |
| Uthayakumar and Priyan [143] | Integrated | Constant | ✓ | ✓ | — | — | ✓ | — |
| Chiu et al. [144] | Integrated | Price dependent | — | — | — | ✓ | — | — |
| Huang et al. [145] | EPQ | Constant | — | — | — | — | — | — |
| Ouyang et al. [146] | EOQ | Constant | — | — | ✓ | ✓ | — | — |
| Soni [147] | EOQ | Price and stock dependent | — | ✓ | — | — | ✓ | — |
| Shah et al. [148] | integrated | Price dependent | — | — | — | — | — | — |
| Liao et al. [149] | EOQ | Constant | — | ✓ | — | — | ✓ | — |
| He and Huang [150] | EOQ | Credit dependent | — | ✓ | ✓ | — | — | — |
| Chuang et al. [151] | Integrated | Constant | — | — | — | ✓ | — | — |

TABLE 1: Continued.

| Author | Model | Demand type | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| Lou and Wang [152] | EPQ | Constant | — | — | ✓ | — | — | — |
| Chung et al. [153] | EOQ | Constant | — | — | — | ✓ | — | — |
| Janková et al. [154] | EOQ | Time dependent | — | — | — | — | — | — |
| Singh and Sharma [155] | EPQ | Stock dependent | — | ✓ | — | — | — | — |
| Chung et al. [156] | EOQ | Constant | — | ✓ | — | ✓ | — | ✓ |
| Pal and Chandra [157] | EOQ | Stock dependent | ✓ | — | — | — | — | — |
| Tung et al. [158] | EOQ | Constant | — | ✓ | — | — | — | — |
| Wang et al. [159] | EOQ | Credit dependent | — | ✓ | — | — | — | — |
| Molamohamadi et al. [160] | EPQ | Price dependent | ✓ | ✓ | — | — | — | — |
| Bhunia et al. [161] | EOQ | Constant | ✓ | ✓ | — | — | ✓ | — |
| Moussawi-Haidar et al. [162] | Integrated (three echelons) | Constant | — | — | — | — | — | — |
| Chern et al. [163] | Noncooperative | Credit dependent | — | — | — | — | — | — |
| Liao et al. [164] | EOQ | Constant | — | ✓ | ✓ | — | ✓ | — |
| Li et al. [165] | EOQ (multiple retailers) | Constant | — | — | — | — | — | — |
| Chen et al. [166] | EPQ | Constant | — | ✓ | ✓ | — | — | — |
| Wu et al. [167] | EOQ | Price and stock dependent | — | ✓ | — | — | ✓ | — |
| Chen and Teng [168] | EOQ | Constant | — | ✓ | — | — | — | — |

*Constant: linear function of time, quadratic function of time, exponential function of time, stock dependent, price dependent, and price and stock dependent.
*Note.* Column A stands for shortage, B for deterioration, C for two-level trade credit, D for order-quantity-dependent trade credit, E for limited storage space, and F for inflation/time value of money. For the answers, ✓ for Yes and — for No.

supplier and manages its cash through the supplier's bank. They also assumed that the bank provides the supplier with a discount on the borrowing rate and demonstrated that this coordination would lead to considerable cost reduction. By assuming credit-dependent demand, Chern et al. [163] formulated the EOQ model for a vendor and his buyer in which none of them has a dominant power over the other. Under a noncooperative Nash equilibrium, they obtained the optimal replenishment time of the buyer as well as the vendor's optimal production cycle time and credit period. Li et al. [165] studied both joint ordering problem and inventory games of multiple retailers who buy the same commodities from a supplier and are offered a permissible delay in payment. Their obtained results showed that formation of grand coalition of retailers is socially beneficial.

## 3. The Models with One of the Factors

This section discusses and classifies the trade credit models based on whether they have considered shortage, deteriorating items, two-level trade credit, order quantity-dependent trade credit, limited storage space, or inflation/time value of money.

*3.1. The Models with Allowable Shortage.* In practice, some industries face extremely high shortage costs, which necessitate maintaining a specific level of inventory to prevent shortages. A good example of this case is the blood bank which has infinitely large shortage cost for being a matter of life and death. On the other hand, there are some situations in which shortage at the time of order is not very significant and its cost is actually negligible. For instance, shortages at time of the valentine gifts ordering would not be influential

to the customers provided the gifts are delivered on time. Subsequently, the buyer prefers using the shortage model as a strategy for reducing the inventory holding cost while increasing the order quantity.

Since shortages affect the quantity ordered, particularly in a delay in payment model, they are of great significance in providing benefits [15]. Respecting this fact, some of the studies carried out in the area of delayed payment have considered shortages, which are completely or partially backlogged.

Chung and Huang [73] generalized Goyal's [7] model by developing a new inventory model with allowable shortages. Hu and Liu [92] extended Chung and Huang [73] to the EPQ framework with shortages and unequal selling and purchasing prices. Under uncertain demand and controllable lead time and ordering cost, Arkan and Hejazi [110] obtained the best value for the credit period in a centralized two-echelon supply chain in which the trade credit policy is applied as a coordination mechanism for a supplier and a retailer. Having considered a two-echelon supply chain, Su [121] formulated an integrated inventory model under trade credit, where shortages and defective items (including still useful and waste items) are assumed. Taleizadeh et al. [134] presented an EOQ model under partial trade credit and partial backlogging to determine the optimal replenishment decisions and shortage level. Partial backlogging is the case that a portion of the shortages are completely backlogged and the rest are fully lost. By establishing an EPQ inventory model with backorder under trade credit, Ouyang and Chang [138] obtained the optimal production policy and backorder level. They assumed that some imperfect items may be produced which need smaller additional cost of reworking. Khanra et al. [141] studied an EOQ model for an item with time varying

quadratic demand while shortages and delay in payments are assumed. Pal and Chandra [157] determined the optimum ordering policy and price discount in a periodic review inventory model with stock-dependent demand and partial backlogging where the discount is offered for backordered demands.

### 3.2. The Models with Deteriorating Items.

Inventory control of the items which deteriorate during the time is a research area with outstanding conducted works. Deterioration is the decline in the quality, quantity, or effectiveness of an item in a way that it could no longer be used for the expected aim it was primarily designed for. Approximately, all the goods and products deteriorate and lose their values partially or completely over time. For some, such as hardware, glassware, and toys, the deterioration rate is insignificant and can be neglected, while, for others, like food stuff, medicine, and food grain, this rate is substantially high. This implies the importance of regarding deterioration rate in formulating the inventory models and producing more accurate results.

For extending Goyal [7], Aggarwal and Jaggi [12] considered deterioration rate where the customer earns interest not only during the credit period, but also beyond it. Hwang and Shinn [14] established an inventory model for deteriorating item with price-sensitive demand and determined the optimal selling price and replenishment policy under trade credit contract. Chu et al. [17] demonstrated that the total cost function presented in Aggarwal and Jaggi [12] is not convex in general and improved their solution procedure. Jamal et al. [20] distinguished the purchasing cost from the selling price in a cost minimization EOQ model for deteriorating items and obtained the retailer's optimal cycle time as well as payment time when paying the remaining balance at a time between the credit period and the cycle time might be more profitable.

Considering the same model as Hwang and Shinn [14], Chung et al. [22] gave a rigorous proof to the concavity of their proposed model and presented an algorithm to find the optimal cycle time. Having assumed the same selling price and purchasing cost, Chang et al. [23] obtained the optimal replenishment time in an EOQ inventory model with two types of deterioration, linear as well as Weibull deterioration rates. Chang and Teng [34] developed Goyal's [7] model to the case of deterioration and cash discount and compared the proposed model with the classical economic order quantity. Ouyang et al. [36] studied an economic order quantity model for deteriorating items when the supplier offers cash discount and permissible delay in payment to the retailer (two-part trade credit). They obtained the optimal ordering policy and compared it to the classical EOQ model in which the payment is settled at the time of delivery.

Considering different selling price and purchasing cost, Teng et al. [37] established an EOQ model for deteriorating items with price-sensitive demand. They found the optimum selling price and replenishment policies and challenged the results obtained in Goyal [7], Aggarwal and Jaggi [12], and Jamal et al. [20]. They concluded that under trade credit, the cycle time and order quantity will decrease. Ouyang et

al. [49] established an EOQ model for noninstantaneous deteriorating items under permissible delay in payment and generalized some previous studies including Goyal [7] and Teng [24]. Noninstantaneous deterioration, defined by Wu et al. [46], is applicable for the goods such as fish and fruits that have a span of maintaining fresh quality during which almost no spoilage occurs. Afterwards, however, these items will start to decay.

Huang and Liao [65] discussed Chang and Teng [34] as a special case in their model and challenged their solution's imperfection in considering small deterioration rate during the cycle time. They proved that without making any assumptions, the total cost formulated in their model is convex. Tsao and Sheen [67] developed an inventory model for deteriorating items with price and time sensitive demand to determine the optimal retail price, promotional effort, and replenishment quantity under dynamic decisions. Chung [70] challenged the process of proofs in Ouyang et al. [49] and presented complete proofs for their proposed theorems to overcome their shortcoming. Roy and Samanta [99] presented an extension of Goyal [7] in which two different rates of production, deteriorating items, and different selling and purchasing values are assumed. Chung [101] removed the assumption of total cost convexity in Huang and Liao [65] and proposed some simplified solution procedures for the same problem to improve their suggested algorithm. Under trade credit policy, Khanra et al. [106] determined the optimal order quantity in an EOQ model for a deteriorating item with quadratic time-dependent demand. With quite similar assumptions to Ouyang et al. [49] and Chung [70], Musa and Sani [111] generalized Goyal's [7] model by incorporating noninstantaneous deterioration. Das et al. [128] studied an integrated system consisting of a supplier's production inventory model and a retailer's EOQ model where the supplier provides the retailer with a delay period for deteriorating item. Liao et al. [129] assumed greater demand rate before deterioration sets in, improved and completed Musa and Sani [111] mathematically, and simplified their proposed solution procedure. Singh and Sharma [155] generalized Sarkar's [115] model to the case of deterioration and demand-dependent production. Tung et al. [158] provided a patch work for Chang et al. [23] to assist researchers in absorbing and applying their important findings. Wang et al. [159] proposed an EOQ model of a vendor and determined his optimal cycle time and credit period for the products with credit-dependent demand and maximum lifetime. Chen and Teng [168] established an EOQ model under trade credit contract for continuously deteriorating items with maximum lifetime and determined the retailer's optimal replenishment cycle time.

### 3.3. The Models Considering Two-Level Trade Credit.

Many of the researchers believe it would be more applicable to consider that not only the supplier provides the retailer with trade credit, but also the retailer gives their customers the chance to pay with delay.

Ventura [8] believed that Goyal's [7] model could be extended by assuming a two-level trade credit, where not only the supplier but also the retailer grants his downstream

level with permissible delay in payment. Later, Huang [30] considered a two-level trade credit and extended Goyal's [7] proposed model. He assumed that the retailer would only allow the customers who buy at time $t$ belonging to $[0, N]$ a credit period of $N - t$ to settle the account. Teng et al. [47] generalized Goyal [7], Teng [24], and Huang [30] by establishing an EPQ inventory model under two levels of trade credit, unequal selling and purchasing prices, unrestricted interest earned and charged, and price-dependent demand rate. Huang [51] viewed an EPQ model under two levels of trade credit from Teng's [24] perspective to generalize Chung and Huang [29] and Huang [30]. In order to extend the presented model by Goyal [7], Teng et al. [52] assumed a two-level trade credit in which the selling price can be higher than the purchasing cost, and also the interest charged is not necessarily greater than the interest earned. They developed the EOQ model with trade credit financing and provided a simple closed-form solution. Besides considering unequal selling and purchasing costs, Teng and Goyal [55] revised Huang's [30] EOQ model by considering a fixed credit period and assessing the retailer's earned interest from the time the customers pay for the goods, not from the beginning. They further extended it by relaxing the assumptions that the customer's trade credit must be smaller than the retailer's trade credit and the interest charged is greater than the interest earned. Su et al. [56] studied an integrated supplier-retailer inventory model under two levels of trade credit, where the customers' demands are sensitive to the length of the credit period offered by the retailer. Huang and Hsu [62] also extended Huang [30] by assuming that the retailer offers his customers only a partial trade credit and relaxed the limitations on the selling and purchasing prices, the interest earned and paid rates, and the retailer's and customer's credit periods. Another extension of Huang's [30] model is represented in Jaggi et al. [66] where demand is assumed to be credit-linked and the cost of an item is considered to be different from its selling price.

By relaxing the limitations on retailer's and supplier's offered credit periods, selling and purchasing prices and interest charged and earned, Thangam and Uthayakumar [68] developed an EPQ inventory model under retailer's full trade credit and customer's partial delay in payment. In a full trade credit, so-called trade credit throughout the paper, the buyer is allowed to delay paying for all the received items from the vendor until the predefined period. Tsao [69] extended Hunag [30] by considering advance sales discount as well as two-level trade credit in a supply chain with one supplier and one retailer. For risk avoiding, Teng [74] assumed that the retailer receives complete trade credit from the supplier but offers a partial trade credit, not necessarily smaller than the provided credit period by the supplier, with collateral deposits to his credit-risk customers and a full trade credit to the good credit customers. His proposed EOQ model can be considered as a general framework for Goyal [7], Teng [24], Huang [30], and Teng and Goyal [55].

Besides complementing the shortcoming of the model proposed by Huang [51] in calculating the interest earned, Teng and Chang [75] extended it by considering the retailer's

credit period and customer's allowed delay period independently. Zhang et al. [88] established an EPQ model from the supplier's perspective under a two-level trade credit in a noncooperative approach to determine the supplier's optimal trade credit decisions. Under two levels of trade credit with cash discount and different selling and purchasing prices, Feng et al. [95] proposed an EOQ inventory model for imperfect quality items to find the retailer's optimal ordering policies. They assumed that the trade credit offered to the retailer is independent of the delay period proposed to the customers. Jaggi and Verma [96] represented a general framework of Goyal [7], Chung [16], Teng [24], Teng and Goyal [55], and Teng [74] by investigating a two-level partial trade credit in an EOQ framework.

An extension of Su et al. [56] was developed in Ho's [98] formulated integrated model where the demand is linked to both the retail price and delay period, and the credit period offered by the supplier is not necessarily larger than the delay period provided by the retailer. Kreng and Tan [104] studied a two-level trade credit inventory system in an EPQ context with defective items, involving both imperfect and scrap items, and finite replenishment rate to find the wholesaler's optimal replenishment policy. Lin et al. [112] maximized the net profit of an integrated supplier-retailer inventory model with credit-dependent demand under two levels of trade credit and the assumption that the retailer may receive some defective items. Teng and Lou [118] determined the supplier's optimal credit period and order time when demand is dependent on the delay period and the retailer's credit period is independent of the customer's delay period.

Chung [120] generalized Su et al. [56] and simplified their proposed algorithm by including transportation cost in the integrated inventory model and applying calculus approach to obtain the optimal solution. Soni and Patel [123] investigated the effect of defective items on an integrated inventory model under two levels of trade credit policy with variable production rate and price-dependent demand. In their proposed model, it is assumed that the supplier adopts a full trade credit to the retailer who offers only a partial trade credit to the customers. Within EPQ framework, Feng et al. [131] obtained a retailer's optimal replenishment time and payment policy under a two-level trade credit with two-part retailer's trade credit. They introduced Goyal [7], Teng [24], Chung and Huang, [29], Huang [30], Huang and Chung [32], Huang [38], Huang et al. [57], Teng [74], and Teng and Chang [75], as some special cases of their presented model. By assuming a complete retailer's trade credit and partial customer's trade credit, price and credit dependent demand, and profit sharing contract, Giri and Maiti [132] established a two-echelon supply chain model with the objective of determining the manufacturer-retailer coordination policy. Lou and Wang [152] developed an EPQ inventory model for defective items under two independent levels of trade credit and determined the manufacturer's optimal replenishment time with the objective of maximizing his total net profit. They introduced Goyal [7], Teng [24], Huang [30], Teng and Goyal [55], and Kreng and Tan [104] as the special cases of their proposed model and complemented the shortcoming of

Kreng and Tan [104] in calculating the manufacturer's earned interest.

*3.4. The Models Considering Order-Quantity-Dependent Trade Credit.* In business, some of the suppliers propose permissible delay in payment to the retailers with greater order quantities to stimulate their size of orders and benefit from the economies of scale in purchasing, manufacturing, and transportation. There is also, another kind of contract in which the suppliers offer shorter credit periods or partial trade credit for smaller quantity of orders and provide the retailers with a greater delay period for more than a certain volume. These kinds of business transactions are called order quantity-dependent trade credit and have been given thought by some of the researchers.

Within the EOQ framework, Khouja and Mehrez [13] investigated the effect of different payment policies including trade credit contract on the optimal order quantity when the credit terms are linked to the quantity of orders. Under order quantity-dependent trade credit and price-linked demand, Shinn and Hwang [26] formulated the retailer's mathematical EOQ model to acquire its optimal order size and price. Chung et al. [35] discussed a few different credit policies from Khouja and Mehrez [13] by assuming that the retailer borrows the total purchasing cost from a bank and keeps it till the end of the inventory cycle time and developed some comparisons with Goyal's [7] model. Huang [50] established an economic order quantity model in which the supplier provides the retailer partially permissible delay in payment for the order quantities smaller than a predetermined quantity and offers him complete trade credit otherwise. Hsu et al. [60] generalized Goyal [7] and Khouja and Mehrez [13] to investigate the effect of order quantity-dependent delay in payments on the EOQ model. Chang et al. [76] extended previous researches including Khouja and Mehrez [13] and Abad and Jaggi [27] by formulating a vendor-buyer integrated inventory model under the order quantity-linked trade credit, selling price-dependent demand, and demand-related production rate. Ouyang et al. [79] formulated an integrated inventory model of a supplier and a buyer when demand is price sensitive and the credit period offered by the supplier depends on the buyer's order size. Ouyang et al. [85] extended the EOQ model proposed by Huang [50] to consider defective items. Teng et al. [108] modelled a vendor-buyer inventory system with order quantity-dependent trade credit contract and determined the optimal solution under two different scenarios: a noncooperative Nash equilibrium with no dominating firm and an integrated model, in which both vendor and buyer are considered as a single firm. Shah et al. [125] studied order quantity-dependent trade credit to formulate an integrated supply chain model with time and price-sensitive quadratic demand. Chung [127] formulated an EOQ inventory model of a retailer who is offered partial order-quantity-dependent credit period by the supplier and may receive defective items. Chiu et al. [144] presented an integrated inventory model of a manufacturer and a buyer with quantity-order-dependent trade credit and imperfect quality products. They assumed that the buyer borrows the

total purchasing cost from the bank and returns it at the end of the replenishment cycle. Considering constant demand rate in Chang et al.'s [76] model, Chuang et al. [151] proposed an integrated inventory model for defective items and determined the optimal replenishment policy and defective rate. They assumed that the vendor provides full trade credit for orders greater than a special amount and offers partial trade credit otherwise. Chung et al. [153] generalized Huang's [50] formulated model by assuming independent interest charged and earned and different selling and purchasing prices and proposed a new procedure to find the retailer's optimal replenishment time.

*3.5. The Models with Limited Storage Space.* Limited storage space is a virtually new constraint added to the permissible delay in payment contracts to simulate the real-world with limitation on the storage capacity. Hence, buyers would not be able to order as much as they want and must consider this certain restriction in decision making. Zhong and Zhou [136] determined the retailer's optimal order quantity and the supplier's optimal credit period both in an integrated inventory model and under a supplier-stackelberg game structure. They assumed that demand rate is related to the inventory level and showed that trade credit policy increases the profitability of the supplier, the retailer, and the whole channel as well.

*3.6. The Models with Inflation/Time Value of Money.* Although most of the studies have considered constant inventory system costs during the planning horizon, some of the researchers took inflation or the time value of money into consideration to provide general and more precise results. Chung [10] extended Chapman et al. [6] and Haley and Higgins [5] by formulating a model that takes the value of money into account. He used the discounted cash flows approach and compared the results with theirs. Teng [40] obtained the optimal order policies through DCF method, when both cash discount and delay in payment are offered and compared their results with Ouyang et al. [36].

## 4. The Models Contributing Two Factors Simultaneously

This chapter refers to the papers that considered two of the previously mentioned factors in their modeling assumptions.

*4.1. The Models with Shortage and Deterioration.* Jamal et al. [15] developed Aggarwal and Jaggi [12] to the case of permissible shortages in inventory. Goyal [7] and Jamal et al. [15] are two special cases of the formulated model by Chang and Dye [21] in which a time varying deterioration rate and partially backlogged shortages are included. Ouyang et al. [41] generalized Teng's [24] model for deteriorating items and partial backlogging. Wu et al. [46] formulated the EOQ inventory model for noninstantaneous deteriorating items in which stock-sensitive demand and partially backlogged shortages with waiting time-dependent rate are assumed. Moreover, they considered the models with instantaneous

or noninstantaneous deterioration rate and with or without shortages as the special cases. Chen and Ouyang [48] fuzzified the time parameters and compared its results with the model proposed in Jamal et al. [15]. Under permissible delay in payment, Yu [135] examined an integrated inventory system for deteriorating items with price-sensitive demand and completely backordered shortage. Their study led to the conclusion that supplier-buyer collaboration results in extra profit gain. Molamohamadi et al. [160] formulated an EPQ model of an exponentially deteriorating item with price-sensitive demand under trade credit, where shortages are considered. Moreover, they applied cuckoo search algorithm for solving the model and demonstrated the effectiveness of trade credit over the classical inventory system. Cuckoo search is a stochastic optimization algorithm introduced by Yang [169] in 2009 and is inspired by the obligate brood parasitism of cuckoo birds.

### 4.2. The Models with Deterioration and Two-Level Trade Credit.
An extension of Huang's [30] work with regard to different selling price and purchasing cost is presented in Liao [63] to investigate the effect of a fixed credit period on the EPQ model with deteriorating items. De and Goswami [71] formulated two EOQ models under two-level trade credit, one with discrete cycle time and the other with continuous cycle time. They supposed exponentially deteriorating items with probabilistic demand to determine the optimal ordering policies. Thangam and Uthayakumar [78] amended Jaggi et al.'s [66] model by formulating an EPQ-based inventory model for perishable items and price and credit-linked demand under two-level trade credit, where the retailer's credit period is not necessarily smaller than the supplier's. Min et al. [93] addressed a two-level trade credit in an EOQ framework where the demand for deteriorating items depends on the retailer's current-stock level. They discussed Goyal [7], Huang [30], and stock-dependent demand in Sana and Chaudhuri [59] as special cases of their model.

Besides relaxing the limitations on supplier and manufacturer credit periods and the earned and paid interest rates, Chang et al. [94] amended Liao [63] by calculating the interest earned from the time that the manufacturer is paid, not from the time zero and obtained the manufacturer's optimal replenishment policy. Dye and Ouyang [97] proposed an EOQ mixed-integer nonlinear programming model under two levels of trade credit for deteriorating items with time-varying demand and applied a traditional particle swarm optimization (PSO) algorithm to solve it. PSO is a population-based search algorithm introduced by Kennedy and Eberhart [170] for finding optimal regions of complex search spaces through the interaction of individuals in a population of particles. A generalization of Goyal [7], Chung and Huang [29], Huang [30], and Huang [51] is represented in Mahata [109] where an economic production quantity model is formulated for exponentially deteriorating items under two levels of trade credit with the assumption that the customer's partial credit period is not necessarily smaller than the retailer's complete credit agreement. Unlike previous studies, Thangam [122] incorporated both advance

payment and trade credit to obtain the optimal replenishment and price discounting policies in an EOQ framework with exponentially deteriorating items and independent retailer's and customer's delay periods. He and Huang [150] developed an EOQ inventory model for noninstantaneous deteriorating items under two levels of trade credit to incorporate Ouyang et al. [49] and Jaggi et al. [66]. Chen et al. [166] reformulated Mahata's [109] proposed model by calculating the earned and paid interest based on the facts that (I) the retailer earns interest from the time he is paid by the customers and (II) the retailer's interest payable must be calculated based on the total items in stock, not only the unsold finished products. Many previous models such as Goyal [7], Teng [24], Teng [74], and Teng and Goyal [80] are mentioned as special cases of their proposed model.

### 4.3. Models with Deterioration and Order Quantity-Dependent Trade Credit.
Chang et al. [31] generalized Teng [24] by presenting an EOQ inventory model under the conditions of order quantity-dependent permissible delay in payment and exponentially decaying inventory with time-varying parameters. Chung and Liao [33] incorporated Khouja and Mehrez [13] and Hwang and Shinn [14] to determine the economic order quantity for deteriorating items where the trade credit is order dependent. Ouyang et al. [72] extended Goyal's [7] model by assuming different selling and purchasing costs, unequal interest earned and charged, deterioration rate, and order-dependent trade credit. They supposed that the retailer is offered a full trade credit if the order quantity is equal to or greater than a specified amount by the supplier and may be suggested a partial trade credit otherwise. They introduced Goyal [7], Aggarwal and Jaggi [12], Teng [24], Chang et al. [31], Chung and Liao [33], and Huang [50] as some special cases of their proposed model.

### 4.4. Models with Deterioration and Limited Storage Space.
Considering storage limitation for a deteriorating item with constant demand, Chung and Huang [44] established an EOQ model and determined the optimal replenishment cycle under trade credit contract. In their proposed model, the rented warehouse is assumed to have the same deterioration rate as the owned warehouse but charges higher inventory holding cost. Liang and Zhou [100] minimized the total inventory costs of an EOQ model considering deteriorating items and constrained storage capacity. They assumed that besides the owned warehouse, the retailer can rent another warehouse with better preserving facilities but higher holding cost. Teng et al. [107] generalized Soni and Shah [58] by assuming positive ending inventory, limited storage space, and exponentially deteriorating items. Soni [147] obtained the optimal replenishment time and quantity of orders in an inventory system involving noninstantaneous deteriorating item under permissible delay in payment. They assumed that the demand is price and stock dependent and the amount of displayed space is limited. In a two-warehouse inventory system, Liao et al. [149] assumed that the deterioration rate in the rented warehouse is greater than that of the retailer's

owned warehouse. Their findings can help the decision makers to recognize whether renting a warehouse is economic or not. Wu et al. [167] complemented the shortcomings of Soni's [147] formulated model by assuming that the ending inventory would be sold as salvages and taking all possible cycle time into consideration.

*4.5. Deterioration and Inflation/Time Value of Money.* Jaggi and Aggarwal [11] extended Chung [10] by considering deteriorating items. Liao et al. [19] developed an inventory model under permissible delay in payments when the consumption rate is initial stock dependent and the deterioration rate is dependent on time. Chung and Lin [103] disproved the approximations made by Jaggi and Aggarwal [11] resulting in deterioration ignorance and making the assumption of deterioration meaningless. Concerning the same problem as Jaggi and Aggarwal [11], they proposed an algorithm to find the optimal cycle time for the case that payment is met whenever the item is sold in a predefined period. Balkhi [105] established a finite horizon inventory model with fixed credit period, time-dependent demand, deteriorating items, inflation, and time value of money. His study led to the conclusion that trade credit contract outperforms the traditional inventory policy. Hou and Lin [142] presented an EOQ inventory model for deteriorating items under trade credit. They obtained the optimal ordering and pricing policies and discussed the effects of inflation, deterioration, and permissible delay in payment.

*4.6. Models with Two-Level and Order-Quantity-Dependent Trade Credit.* Within the EOQ framework, Kreng and Tan [89] found the optimal replenishment decisions when two-level quantity-order-dependent trade credit and defective items are involved. They demonstrated that relaxing different assumptions of their model would lead to the models proposed by Goyal [7] and Huang [30]. Teng et al. [140] proposed an EOQ inventory model for time-increasing demand under two-level trade credit and retailer's order-size-dependent trade credit to generalize Goyal [7], Teng [24], Huang [30], Teng and Goayl [55], and Teng et al. [116]. They determined the optimal replenishment cycle and order quantity with the objective of minimizing the retailer's total cost. Besides overcoming the shortcomings of Kreng and Tan [89] in calculating the earned and charged interest, Ouyang et al. [146] extended their model by assuming independent supplier and wholesaler credit periods and relaxed the assumption that the wholesaler's earned interest is smaller than its charged interest. Theoretical results are finally established to minimize the total cost.

*4.7. Models with Two-Level Trade Credit and Limited Storage Space.* Adopting Teng's [24] and Huang's [30] viewpoints, Huang [43] investigated the retailer's inventory policy under two-levels of trade credit provided that the retailer's selling price is not necessarily equal to the purchasing cost and the storage space is limited. Teng et al. [81] generalized Huang's [43] inventory model by assuming that the credit period offered by the supplier and the interest charged are not

necessarily greater than the retailer's suggested delay period and the interest earned, respectively. They also complemented the shortcoming of his model by calculating the retailer's earned interest from the time he is paid by the customers. Furthermore, they proposed a simple method to obtain the optimal solution without derivatives. Chung [113] formulated an EPQ model under two-level trade credit, from the Huang [30] viewpoint, limited storage capacity and different selling and purchasing prices to generalize Chung and Huang [29] and Huang, [30], Huang [43], Huang [51], Y.-F. Huang and H.-F. Huang [61], and Chung [86].

*4.8. Models with Order-Quantity-Dependent Trade Credit and Inflation/Time Value of Money.* Chung and Liao [77] developed an EOQ model under order-quantity-dependent trade credit and DCF approach to generalize Chung [10]. They obtained the buyer's optimum order quantity when the buyer pays to the supplier at the time of using the materials in a predetermined period and pays off the balance at the end of this period.

# 5. The Models Incorporating More Than Two Factors

There are some other models including three or more factors in the model formulation to make it closer to the real world. Sarker et al. [18] extended Aggarwal and Jaggi [12] and Jamal et al. [15] by considering inflation and shortage to obtain the optimal replenishment policy for deteriorating items when delay in payment is permitted. In the presence of order-linked trade credit and discounted cash flows, Chung and Liao [42] developed an EOQ model for deteriorating items to generalize Jaggi and Aggarwal [11].

Under two-level trade credit, Chung and Huang [53] developed Huang [30] by establishing an EOQ model for deteriorating items with limited storage capacity. By adopting a DCF approach, Yang [82] studied an EOQ model for deteriorating items where the supplier provides the retailer either a conditionally permissible delay in payment or a cash discount. Their research is an extension of Chung [10], Jaggi and Aggarwal [11], Teng [40], and Chung and Liao [42]. Chang et al. [84] amended Wu et al.'s [46] formulated model by maximizing the objective function, limiting the inventory level, and relaxing the restriction of zero ending inventory when shortages are not desirable. Liao and Huang [87] incorporated DCF approach and deterioration rate to extend Huang [30]'s inventory model. Moreover, Thangam and Uthayakumar [90] incorporated storage capacity and perishable items and modified the demand function to price sensitive to amend Huang and Hsu [62].

Chang et al. [91] adopted a DCF approach to establish an EOQ model for deteriorating items where credit period and price discount depend on the quantity ordered. Liao et al. [114] incorporated both Chung and Liao [33] and Chung and Huang [44] in an EOQ model for deteriorating items with order-size-dependent trade credit and limited storage space and determined the optimal order quantity. Under a two-level trade credit policy and in a profit maximization

EOQ inventory system with backorder, Dye [119] determined the optimal selling prices and replenishment number and scheme when the demand for deteriorating items is linked to both price and time. Guchhait et al. [126] evaluated the effect of order-quantity-dependent trade credit on retailer's replenishment policy for exponentially deteriorating items in a two-warehouse inventory model. They assumed that the supplier offers a full trade credit to the retailer for the quantity of orders more than a specified amount and provides partial trade credit otherwise.

From the viewpoint of profit maximization, Yang and Chang [130] developed an inventory model, including two warehouses with different deterioration rates, fixed credit period, and partially backlogged shortages to determine the optimal replenishment policy when inflation is taken into account. Soni [133] extended the proposed model by Min et al. [93] to avoid having zero ending inventory and included storage space limitation. Annadurai and Uthayakumar [139] reformulated Jaggi et al. [66] by considering deteriorating items and allowable shortages. So, they proposed an EOQ inventory model for deteriorating items with credit-dependent demand under two levels of trade credit and completely backlogged shortages to obtain the retailer's optimal ordering policy. Under trade credit policy, backorder, deterioration, and limited storage space, Uthayakumar and Priyan [143] developed an integrated inventory model of a hospital and a pharmaceutical company in which the latter procures multiple products, which may include defective items for the former with variable lead time. They minimized the total cost of the supply chain by finding the optimal order quantity, lead time, and number of deliveries. Chung et al. [156] reformulated the model presented in Yang [82] to overcome its shortcomings and proposed the complete mathematical proofs for their results. Considering two warehouses with different facilities, Bhunia et al. [161] developed an inventory model for a deteriorating item with constant demand and partial waiting time-dependent backorder. Assuming a two-level trade credit and limited storage space for deteriorating items, Liao et al. [164] modelled an EOQ inventory system of a retailer who pays the supplier at the end of delay period whenever he has money and delays incurring interest charges on the unpaid and overdue balance due to the difference between interest earned and interest charged.

## 6. Conclusion

In this paper, an up-to-date review of inventory models under permissible delay in payment has been provided since Haley and Higgins formulated an EOQ model with delay in payment in 1973. The relevant models are classified into six major categories, and the results are represented as a table. Finally, we discussed the models in more detail based on their incorporated factors to disclose useful information with respect to the models' extensions.

The literature review presented in this research shows that although many researches have been conducted in this area of science, it has still great potential to be further extended. Another conclusion is that Goyal's [7] model can

be considered as the major infrastructure for the inventory models with delay in payment. A more precise look at the trend of the literature reveals that most of the studies discussed here are extensions of their preceding researches to which one or more factors mentioned throughout this paper are added.

A more thorough summary of the findings of this literature review is as follows. First of all, this paper reveals that most of the previous studies have considered EOQ model, but recently integrated inventory models have attracted the attention of a considerable number of researchers. This consideration is practical in the real world as the parties of the supply chain (supplier and buyer) seek for their profit maximization simultaneously. Moreover, EPQ models are still suitable for future studies. Secondly, it is mostly assumed that the demand rate is constant. However, clearly, this assumption is only for the time that the product is in the maturity stage of its life cycle. Therefore, considering time, price, or credit-dependent demand rate would be of great importance and could be considered as one of the main directions toward conducting future researches. Thirdly, many suppliers allow the buyers with the quantity of orders greater than or equal to a predetermined quantity to delay the payment in order to intrigue the buyers to order in larger quantities. Since this assumption is not considered widely, a more realistic and effective problem for the future research could be considering order-quantity-dependent trade credit. Fourthly, it is argued by some of the previously conducted studies that backorder occurs partially, not completely, and some of the customers may be lost due to the lack of the inventory. This could be assumed for future studies to extend the existing models.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

## Acknowledgments

## References

[1] D. Piasecki, "Consignment inventory: what is it and when does it make sense to use it?" White Paper, Inventory Operations Consulting, 2004.

[2] Z. Molamohamadi, M. Rezaeiahari, and N. Ismail, "Consignment Inventory: review and Critique of Literature," *Journal of Basic and Applied Scientific Research*, vol. 3, no. 6, pp. 707–714, 2013.

[3] C.-T. Chang, J.-T. Teng, and S. K. Goyal, "Inventory lot-size models under trade credits: a review," *Asia-Pacific Journal of Operational Research*, vol. 25, no. 1, pp. 89–112, 2008.

[4] H. Soni, N. H. Shah, and C. K. Jaggi, "Inventory models and trade credit: a review," *Control and Cybernetics*, vol. 39, no. 3, pp. 867–880, 2010.

[5] C. W. Haley and R. C. Higgins, "Inventory policy and trade credit financing," *Management Science*, vol. 20, no. 4, pp. 464–471, 1973.

[6] C. B. Chapman, S. C. Ward, D. F. Cooper, and M. J. Page, "Credit policy and inventory control," *Journal of the Operational Research Society*, vol. 35, no. 12, pp. 1055–1065, 1984.

[7] S. K. Goyal, "Economic order quantity under conditions of permissible delay in payments," *Journal of the Operational Research Society*, vol. 36, no. 4, pp. 335–338, 1985.

[8] E. Ventura, "Letter and viewpoint," *Journal of the Operational Research Society*, vol. 36, no. 10, pp. 965–967, 1985.

[9] U. Dave, "Letters and viewpoints on "economic order quantity under conditions of permissible delay in payments" by Goyal," *Journal of the Operational Research Society*, vol. 36, no. 11, p. 1069, 1985.

[10] K. H. Chung, "Inventory control and trade credit revisited," *Journal of the Operational Research Society*, vol. 40, no. 5, pp. 495–498, 1989.

[11] C. K. Jaggi and S. P. Aggarwal, "Credit financing in economic ordering policies of deteriorating items," *International Journal of Production Economics*, vol. 34, no. 2, pp. 151–155, 1994.

[12] S. P. Aggarwal and C. K. Jaggi, "Ordering policy for deteriorating items under permissible delay in payments," *Journal of the Operational Research Society*, vol. 46, no. 5, pp. 658–662, 1995.

[13] M. Khouja and A. Mehrez, "Optimal inventory policy under different supplier credit policies," *Journal of Manufacturing Systems*, vol. 15, no. 5, pp. 334–339, 1996.

[14] H. Hwang and S. W. Shinn, "Retailer's pricing and lot sizing policy for exponentially deteriorating products under the condition of permissible delay in payments," *Computers and Operations Research*, vol. 24, no. 6, pp. 539–547, 1997.

[15] A. M. M. Jamal, B. R. Sarker, and S. Wang, "An ordering policy for deteriorating items with allowable shortage and permissible delay in payment," *Journal of the Operational Research Society*, vol. 48, no. 8, pp. 826–833, 1997.

[16] K. Chung, "A theorem on the determination of economic order quantity under conditions of permissible delay in payments," *Computers and Operations Research*, vol. 25, no. 1, pp. 49–52, 1998.

[17] P. Chu, K. Chung, and S. Lan, "Economic order quantity of deteriorating items under permissible delay in payments," *Computers and Operations Research*, vol. 25, no. 10, pp. 817–824, 1998.

[18] B. R. Sarker, A. M. M. Jamal, and S. Wang, "Supply chain models for perishable products under inflation and permissible delay in payment," *Computers and Operations Research*, vol. 27, no. 1, pp. 59–75, 2000.

[19] H. Liao, C. Tsai, and C. Su, "Inventory model with deteriorating items under inflation when a delay in payment is permissible," *International Journal of Production Economics*, vol. 63, no. 2, pp. 207–214, 2000.

[20] A. M. M. Jamal, B. R. Sarker, and S. Wang, "Optimal payment time for a retailer under permitted delay of payment by the wholesaler," *International Journal of Production Economics*, vol. 66, no. 1, pp. 59–66, 2000.

[21] H.-J. Chang and C.-Y. Dye, "An inventory model for deteriorating items with partial backlogging and permissible delay in payments," *International Journal of Systems Science*, vol. 32, no. 3, pp. 345–352, 2001.

[22] K. J. Chung, S. L. Chang, and W. D. Yang, "The optimal cycle time for exponentially deteriorating products under trade credit financing," *Engineering Economics*, vol. 46, no. 3, pp. 232–242, 2001.

[23] H.-J. Chang, C.-Y. Dye, and B.-R. Chuang, "An inventory model for deteriorating items under the condition of permissible delay in payments," *Yugoslav Journal of Operations Research*, vol. 12, no. 1, pp. 73–84, 2002.

[24] J.-T. Teng, "On the economic order quantity under conditions of permissible delay in payments," *Journal of the Operational Research Society*, vol. 53, no. 8, pp. 915–918, 2002.

[25] L. Ouyang, M. Chen, and K. Chuang, "Economic order quantity model under cash discount and payment delay," *International Journal of Information and Management Sciences*, vol. 13, no. 1, pp. 1–10, 2002.

[26] S. W. Shinn and H. Hwang, "Optimal pricing and ordering policies for retailers under order-size-dependent delay in payments," *Computers and Operations Research*, vol. 30, no. 1, pp. 35–50, 2003.

[27] P. L. Abad and C. K. Jaggi, "A joint approach for setting unit price and the length of the credit period for a seller when end demand is price sensitive," *International Journal of Production Economics*, vol. 83, no. 2, pp. 115–122, 2003.

[28] K.-J. Chung and Y.-F. Huang, "Economic ordering policies for items under permissible delay in payments," *Journal of Information & Optimization Sciences*, vol. 24, no. 2, pp. 329–344, 2003.

[29] K. Chung and Y. Huang, "The optimal cycle time for EPQ inventory model under permissible delay in payments," *International Journal of Production Economics*, vol. 84, no. 3, pp. 307–318, 2003.

[30] Y.-F. Huang, "Optimal retailer's ordering policies in the EOQ model under trade credit financing," *Journal of the Operational Research Society*, vol. 54, no. 9, pp. 1011–1015, 2003.

[31] C. Chang, L. Ouyang, and J. Teng, "An EOQ model for deteriorating items under supplier credits linked to ordering quantity," *Applied Mathematical Modelling*, vol. 27, no. 12, pp. 983–996, 2003.

[32] Y.-F. Huang and K.-J. Chung, "Optimal replenishment and payment policies in the EOQ model under cash discount and trade credit," *Asia-Pacific Journal of Operational Research*, vol. 20, no. 2, pp. 177–190, 2003.

[33] K. Chung and J. Liao, "Lot-sizing decisions under trade credit depending on the ordering quantity," *Computers and Operations Research*, vol. 31, no. 6, pp. 909–928, 2004.

[34] C.-T. Chang and J.-T. Teng, "Retailer's optimal ordering policy under supplier credits," *Mathematical Methods of Operations Research*, vol. 60, no. 3, pp. 471–483, 2004.

[35] K. Chung, S. K. Goyal, and Y. Huang, "The optimal inventory policies under permissible delay in payments depending on the ordering quantity," *International Journal of Production Economics*, vol. 95, no. 2, pp. 203–213, 2005.

[36] L.-Y. Ouyang, C.-T. Chang, and J.-T. Teng, "An EOQ model for deteriorating items under trade credits," *Journal of the Operational Research Society*, vol. 56, no. 6, pp. 719–726, 2005.

[37] J. Teng, C. Chang, and S. K. Goyal, "Optimal pricing and ordering policy under permissible delay in payments," *International Journal of Production Economics*, vol. 97, no. 2, pp. 121–129, 2005.

[38] Y.-F. Huang, "Buyer's optimal ordering policy and payment policy under supplier credit," *International Journal of Systems Science*, vol. 36, no. 13, pp. 801–807, 2005.

[39] Y.-F. Huang, "Retailer's inventory policy under supplier's partial trade credit policy," *Journal of the Operations Research Society of Japan*, vol. 48, no. 3, pp. 173–182, 2005.

[40] J. T. Teng, "Discount cash-flow analysis on inventory control under various supplier's trade credits," *International Journal of Operational Research*, vol. 3, no. 1, pp. 23–29, 2006.

[41] L.-Y. Ouyang, J.-T. Teng, and L.-H. Chen, "Optimal ordering policy for deteriorating items with partial backlogging under permissible delay in payments," *Journal of Global Optimization*, vol. 34, no. 2, pp. 245–271, 2006.

[42] K. Chung and J. Liao, "The optimal ordering policy in a DCF analysis for deteriorating items when trade credit depends on the order quantity," *International Journal of Production Economics*, vol. 100, no. 1, pp. 116–130, 2006.

[43] Y. Huang, "An inventory model under two levels of trade credit and limited storage space derived without derivatives," *Applied Mathematical Modelling*, vol. 30, no. 5, pp. 418–436, 2006.

[44] K.-J. Chung and T.-S. Huang, "The optimal cycle time for deteriorating items with limited storage capacity under permissible delay in payments," *Asia-Pacific Journal of Operational Research*, vol. 23, no. 3, pp. 347–370, 2006.

[45] K. Chung and Y. Huang, "Retailer's optimal cycle times in the EOQ model with imperfect quality and a permissible credit period," *Quality and Quantity*, vol. 40, no. 1, pp. 59–77, 2006.

[46] K. Wu, L. Ouyang, and C. Yang, "An optimal replenishment policy for non-instantaneous deteriorating items with stock-dependent demand and partial backlogging," *International Journal of Production Economics*, vol. 101, no. 2, pp. 369–384, 2006.

[47] J. T. Teng, L. Y. Ouyang, and L. H. Chen, "Optimal manufacturer 's pricing and lot-sizing policies under trade credit financing," *International Journal of Operational Research*, vol. 13, no. 6, pp. 515–528, 2006.

[48] L.-H. Chen and L.-Y. Ouyang, "Fuzzy inventory model for deteriorating items with permissible delay in payment," *Applied Mathematics and Computation*, vol. 182, no. 1, pp. 711–726, 2006.

[49] L. Ouyang, K. Wu, and C. Yang, "A study on an inventory model for non-instantaneous deteriorating items with permissible delay in payments," *Computers and Industrial Engineering*, vol. 51, no. 4, pp. 637–651, 2006.

[50] Y. Huang, "Economic order quantity under conditionally permissible delay in payments," *European Journal of Operational Research*, vol. 176, no. 2, pp. 911–924, 2007.

[51] Y. Huang, "Optimal retailer's replenishment decisions in the EPQ model under two levels of trade credit policy," *European Journal of Operational Research*, vol. 176, no. 3, pp. 1577–1591, 2007.

[52] J.-T. Teng, C.-T. Chang, M.-S. Chern, and Y.-L. Chan, "Retailer's optimal ordering policies with trade credit financing," *International Journal of Systems Science*, vol. 38, no. 3, pp. 269–278, 2007.

[53] K. Chung and T. Huang, "The optimal retailer's ordering policies for deteriorating items with limited storage capacity under trade credit financing," *International Journal of Production Economics*, vol. 106, no. 1, pp. 127–145, 2007.

[54] S. K. Goyal, J. Teng, and C. Chang, "Optimal ordering policies when the supplier provides a progressive interest scheme," *European Journal of Operational Research*, vol. 179, no. 2, pp. 404–413, 2007.

[55] J.-T. Teng and S. K. Goyal, "Optimal ordering policies for a retailer in a supply chain with up-stream and down-stream trade credits," *Journal of the Operational Research Society*, vol. 58, no. 9, pp. 1252–1255, 2007.

[56] C.-H. Su, L.-Y. Ouyang, C.-H. Ho, and C.-T. Chang, "Retailer's inventory policy and supplier's delivery policy under two-level trade credit strategy," *Asia-Pacific Journal of Operational Research*, vol. 24, no. 5, pp. 613–630, 2007.

[57] Y.-F. Huang, C.-L. Chou, and J.-J. Liao, "An EPQ model under cash discount and permissible delay in payments derived without derivatives," *Yugoslav Journal of Operations Research*, vol. 17, no. 2, pp. 177–193, 2007.

[58] H. Soni and N. H. Shah, "Optimal ordering policy for stock-dependent demand under progressive payment scheme," *European Journal of Operational Research*, vol. 184, no. 1, pp. 91–100, 2008.

[59] S. S. Sana and K. S. Chaudhuri, "A deterministic EOQ model with delays in payments and price-discount offers," *European Journal of Operational Research*, vol. 184, no. 2, pp. 509–533, 2008.

[60] K. Hsu, H. Huang, Y. Tu, and Y. Huang, "Optimal inventory planning under permissible delay in payments when a larger order quantity," *Journal of Applied Sciences*, vol. 8, no. 6, pp. 1049–1054, 2008.

[61] Y.-F. Huang and H.-F. Huang, "Optimal inventory replenishment policy for the EPQ model under trade credit derived without derivatives," *International Journal of Systems Science*, vol. 39, no. 5, pp. 539–546, 2008.

[62] Y. Huang and K. Hsu, "An EOQ model under retailer partial trade credit policy in supply chain," *International Journal of Production Economics*, vol. 112, no. 2, pp. 655–664, 2008.

[63] J. Liao, "An EOQ model with noninstantaneous receipt and exponentially deteriorating items under two-level trade credit," *International Journal of Production Economics*, vol. 113, no. 2, pp. 852–861, 2008.

[64] C.-H. Ho, L.-Y. Ouyang, and C.-H. Su, "Optimal pricing, shipment and payment policy for an integrated supplier-buyer inventory model with two-part trade credit," *European Journal of Operational Research*, vol. 187, no. 2, pp. 496–510, 2008.

[65] K.-N. Huang and J.-J. Liao, "A simple method to locate the optimal solution for exponentially deteriorating items under trade credit financing," *Computers & Mathematics with Applications*, vol. 56, no. 4, pp. 965–977, 2008.

[66] C. K. Jaggi, S. K. Goyal, and S. K. Goel, "Retailer's optimal replenishment decisions with credit-linked demand under permissible delay in payments," *European Journal of Operational Research*, vol. 190, no. 1, pp. 130–135, 2008.

[67] Y. Tsao and G. Sheen, "Dynamic pricing, promotion and replenishment policies for a deteriorating item under permissible delay in payments," *Computers and Operations Research*, vol. 35, no. 11, pp. 3562–3580, 2008.

[68] A. Thangam and R. Uthayakumar, "Analysis of partial trade credit financing in a supply chain by EPQ-based models," *Advanced Modeling and Optimization*, vol. 10, no. 2, pp. 177–198, 2008.

[69] Y. Tsao, "Retailer's optimal ordering and discounting policies under advance sales discount and trade credits," *Computers and Industrial Engineering*, vol. 56, no. 1, pp. 208–215, 2009.

[70] K. Chung, "A complete proof on the solution procedure for non-instantaneous deteriorating items with permissible delay in payment," *Computers and Industrial Engineering*, vol. 56, no. 1, pp. 267–273, 2009.

[71] L. N. De and A. Goswami, "Probabilistic EOQ model for deteriorating items under trade credit financing," *International Journal of Systems Science*, vol. 40, no. 4, pp. 335–346, 2009.

[72] L.-Y. Ouyang, J.-T. Teng, S. K. Goyal, and C.-T. Yang, "An economic order quantity model for deteriorating items with partially permissible delay in payments linked to order quantity," *European Journal of Operational Research*, vol. 194, no. 2, pp. 418–431, 2009.

[73] K.-J. Chung and C.-K. Huang, "An ordering policy with allowable shortage and permissible delay in payments," *Applied Mathematical Modelling*, vol. 33, no. 5, pp. 2518–2525, 2009.

[74] J. Teng, "Optimal ordering policies for a retailer who offers distinct trade credits to its good and bad credit customers," *International Journal of Production Economics*, vol. 119, no. 2, pp. 415–423, 2009.

[75] J.-T. Teng and C.-T. Chang, "Optimal manufacturer's replenishment policies in the EPQ model under two levels of trade credit policy," *European Journal of Operational Research*, vol. 195, no. 2, pp. 358–363, 2009.

[76] H.-C. Chang, C.-H. Ho, L.-Y. Ouyang, and C.-H. Su, "The optimal pricing and ordering policy for an integrated inventory model when trade credit linked to order quantity," *Applied Mathematical Modelling*, vol. 33, no. 7, pp. 2978–2991, 2009.

[77] K.-J. Chung and J.-J. Liao, "The optimal ordering policy of the EOQ model under trade credit depending on the ordering quantity from the DCF approach," *European Journal of Operational Research*, vol. 196, no. 2, pp. 563–568, 2009.

[78] A. Thangam and R. Uthayakumar, "Two-echelon trade credit financing for perishable items in a supply chain when demand depends on both selling price and credit period," *Computers and Industrial Engineering*, vol. 57, no. 3, pp. 773–786, 2009.

[79] L. Ouyang, C. Ho, and C. Su, "An optimization approach for joint pricing and ordering problem in an integrated inventory system with order-size dependent trade credit," *Computers and Industrial Engineering*, vol. 57, no. 3, pp. 920–930, 2009.

[80] J.-T. Teng and S. K. Goyal, "Comment on 'Optimal inventory replenishment policy for the EPQ model under trade credit derived without derivatives'," *International Journal of Systems Science*, vol. 40, no. 10, pp. 1095–1098, 2009.

[81] J.-T. Teng, J. Chen, and S. K. Goyal, "A comprehensive note on: an inventory model under two levels of trade credit and limited storage space derived without derivatives," *Applied Mathematical Modelling*, vol. 33, no. 12, pp. 4388–4396, 2009.

[82] C.-T. Yang, "The optimal order and payment policies for deteriorating items in discount cash flows analysis under the alternatives of conditionally permissible delay in payments and cash discount," *Top*, vol. 18, no. 2, pp. 429–443, 2010.

[83] L. Chen and F. Kang, "Coordination between vendor and buyer considering trade credit and items of imperfect quality," *International Journal of Production Economics*, vol. 123, no. 1, pp. 52–61, 2010.

[84] C. Chang, J. Teng, and S. K. Goyal, "Optimal replenishment policies for non-instantaneous deteriorating items with stock-dependent demand," *International Journal of Production Economics*, vol. 123, no. 1, pp. 62–68, 2010.

[85] L.-Y. Ouyang, C.-T. Chang, and P. Shum, "The EOQ with defective items and partially permissible delay in payments linked to order quantity derived algebraically," *Central European Journal of Operations Research*, vol. 20, no. 1, pp. 141–160, 2010.

[86] K.-J. Chung, "The optimal inventory policy for EPQ model under trade credit," *International Journal of Systems Science*, vol. 41, no. 9, pp. 1115–1120, 2010.

[87] J.-J. Liao and K.-N. Huang, "An inventory model for deteriorating items with two levels of trade credit taking account of time discounting," *Acta Applicandae Mathematicae*, vol. 110, no. 1, pp. 313–326, 2010.

[88] X. Zhang, G. Dai, H. Shen, X. Jiang, and F. Ding, "The optimal supplier's trade credit decisions in the EPQ model," in *Proceedings of the IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI '10)*, pp. 208–213, July 2010.

[89] V. B. Kreng and S. Tan, "The optimal replenishment decisions under two levels of trade credit policy depending on the order quantity," *Expert Systems with Applications*, vol. 37, no. 7, pp. 5514–5522, 2010.

[90] A. Thangam and R. Uthayakumar, "Optimal pricing and lot-sizing policy for a two-warehouse supply chain system with perishable items under partial trade credit financing," *Operational Research*, vol. 10, no. 2, pp. 133–161, 2010.

[91] C. Chang, L. Ouyang, J. Teng, and M. Cheng, "Optimal ordering policies for deteriorating items using a discounted cash-flow analysis when a trade credit is linked to order quantity," *Computers and Industrial Engineering*, vol. 59, no. 4, pp. 770–777, 2010.

[92] F. Hu and D. Liu, "Optimal replenishment policy for the EPQ model with permissible delay in payments and allowable shortages," *Applied Mathematical Modelling*, vol. 34, no. 10, pp. 3108–3117, 2010.

[93] J. Min, Y.-W. Zhou, and J. Zhao, "An inventory model for deteriorating items under stock-dependent demand and two-level trade credit," *Applied Mathematical Modelling*, vol. 34, no. 11, pp. 3273–3285, 2010.

[94] C. Chang, J. Teng, and M. Chern, "Optimal manufacturer's replenishment policies for deteriorating items in a supply chain with up-stream and down-stream trade credits," *International Journal of Production Economics*, vol. 127, no. 1, pp. 197–202, 2010.

[95] H. Feng, J. Li, and Y. Zeng, "Retailer's optimal replenishment policy with defective products under cash discount and two-level trade credit," in *Proceedings of the International Conference on E-Product E-Service and E-Entertainment (ICEEE '10)*, no. 1, pp. 1–5, November 2010.

[96] C. K. Jaggi and M. Verma, "Ordering policies under supplier-retailer partial trade credit financing," *Opsearch*, vol. 47, no. 4, pp. 293–310, 2010.

[97] C. Dye and L. Ouyang, "A particle swarm optimization for solving joint pricing and lot-sizing problem with fluctuating demand and trade credit financing," *Computers and Industrial Engineering*, vol. 60, no. 1, pp. 127–137, 2011.

[98] C. Ho, "The optimal integrated inventory policy with price-and-credit-linked demand under two-level trade credit," *Computers and Industrial Engineering*, vol. 60, no. 1, pp. 117–126, 2011.

[99] A. Roy and G. P. Samanta, "Inventory model with two rates of production for deteriorating items with permissible delay in payments," *International Journal of Systems Science*, vol. 42, no. 8, pp. 1375–1386, 2011.

[100] Y. Liang and F. Zhou, "A two-warehouse inventory model for deteriorating items under conditionally permissible delay in payment," *Applied Mathematical Modelling*, vol. 35, no. 5, pp. 2221–2231, 2011.

[101] K.-J. Chung, "Some improved algorithms to locate the optimal solutions for exponentially deteriorating items under trade credit financing in a supply chain system," *Computers & Mathematics with Applications*, vol. 61, no. 9, pp. 2353–2361, 2011.

[102] Y.-C. Tsao, "Replenishment policies considering trade credit and logistics risk," *Scientia Iranica*, vol. 18, no. 3, pp. 753–758, 2011.

[103] K.-J. Chung and S.-D. Lin, "The inventory model for trade credit in economic ordering policies of deteriorating items in a supply chain system," *Applied Mathematical Modelling*, vol. 35, no. 6, pp. 3111–3115, 2011.

[104] V. B. Kreng and S. Tan, "Optimal replenishment decision in an EPQ model with defective items under supply chain trade credit policy," *Expert Systems with Applications*, vol. 38, no. 8, pp. 9888–9899, 2011.

[105] Z. T. Balkhi, "Optimal economic ordering policy with deteriorating items under different supplier trade credits for finite horizon case," *International Journal of Production Economics*, vol. 133, no. 1, pp. 216–223, 2011.

[106] S. Khanra, S. K. Ghosh, and K. S. Chaudhuri, "An EOQ model for a deteriorating item with time dependent quadratic demand under permissible delay in payment," *Applied Mathematics and Computation*, vol. 218, no. 1, pp. 1–9, 2011.

[107] J.-T. Teng, I.-P. Krommyda, K. Skouri, and K.-R. Lou, "A comprehensive extension of optimal ordering policy for stock-dependent demand under progressive payment scheme," *European Journal of Operational Research*, vol. 215, no. 1, pp. 97–104, 2011.

[108] J.-T. Teng, C.-T. Chang, and M.-S. Chern, "Vendor-buyer inventory models with trade credit financing under both non-cooperative and integrated environments," *International Journal of Systems Science*, vol. 43, no. 11, pp. 2050–2061, 2012.

[109] G. C. Mahata, "An EPQ-based inventory model for exponentially deteriorating items under retailer partial trade credit policy in supply chain," *Expert Systems with Applications*, vol. 39, no. 3, pp. 3537–3550, 2012.

[110] A. Arkan and S. R. Hejazi, "Coordinating orders in a two echelon supply chain with controllable lead time and ordering cost using the credit period," *Computers and Industrial Engineering*, vol. 62, no. 1, pp. 56–69, 2012.

[111] A. Musa and B. Sani, "Inventory ordering policies of delayed deteriorating items under permissible delay in payments," *International Journal of Production Economics*, vol. 136, no. 1, pp. 75–83, 2012.

[112] Y.-J. Lin, L.-Y. Ouyang, and Y.-F. Dang, "A joint optimal ordering and delivery policy for an integrated supplier-retailer inventory model with trade credit and defective items," *Applied Mathematics and Computation*, vol. 218, no. 14, pp. 7498–7514, 2012.

[113] K.-J. Chung, "The EPQ model under conditions of two levels of trade credit and limited storage capacity in supply chain management," *International Journal of Systems Science*, vol. 44, no. 9, pp. 1675–1691, 2013.

[114] J. Liao, K. Huang, and K. Chung, "Lot-sizing decisions for deteriorating items with two warehouses under an order-size-dependent trade credit," *International Journal of Production Economics*, vol. 137, no. 1, pp. 102–115, 2012.

[115] B. Sarkar, "An EOQ model with delay in payments and stock dependent demand in the presence of imperfect production," *Applied Mathematics and Computation*, vol. 218, no. 17, pp. 8295–8308, 2012.

[116] J. Teng, J. Min, and Q. Pan, "Economic order quantity model with trade credit financing for non-decreasing demand," *Omega*, vol. 40, no. 3, pp. 328–335, 2012.

[117] M.-C. Cheng, C.-T. Chang, and L.-Y. Ouyang, "The retailer's optimal ordering policy with trade credit in different financial

environments," *Applied Mathematics and Computation*, vol. 218, no. 19, pp. 9623–9634, 2012.

[118] J.-T. Teng and K.-R. Lou, "Seller's optimal credit period and replenishment time in a supply chain with up-stream and down-stream trade credits," *Journal of Global Optimization*, vol. 53, no. 3, pp. 417–430, 2012.

[119] C. Dye, "A finite horizon deteriorating inventory model with two-phase pricing and time-varying demand and cost under trade credit financing using particle swarm optimization," *Swarm and Evolutionary Computation*, vol. 5, pp. 37–53, 2012.

[120] K.-J. Chung, "The integrated inventory model with the transportation cost and two-level trade credit in supply chain management," *Computers & Mathematics with Applications*, vol. 64, no. 6, pp. 2011–2033, 2012.

[121] C. Su, "Optimal replenishment policy for an integrated inventory system with defective items and allowable shortage under trade credit," *International Journal of Production Economics*, vol. 139, no. 1, pp. 247–256, 2012.

[122] A. Thangam, "Optimal price discounting and lot-sizing policies for perishable items in a supply chain under advance payment scheme and two-echelon trade credits," *International Journal of Production Economics*, vol. 139, no. 2, pp. 459–472, 2012.

[123] H. N. Soni and K. A. Patel, "Optimal strategy for an integrated inventory system involving variable production and defective items under retailer partial trade credit policy," *Decision Support Systems*, vol. 54, no. 1, pp. 235–247, 2012.

[124] Y.-G. Zhong and Y.-W. Zhou, "The model and algorithm for determining optimal ordering/trade-credit policy of supply chains," *Applied Mathematics and Computation*, vol. 219, no. 8, pp. 3809–3825, 2012.

[125] N. H. Shah, A. S. Gor, and C. A. Jhaveri, "Optimal pricing and ordering policy for an integrated inventory model with quadratic demand when trade credit linked to order quantity," *Journal of Model Management*, vol. 7, no. 2, pp. 148–165, 2012.

[126] P. Guchhait, M. K. Maiti, and M. Maiti, "Two storage inventory model of a deteriorating item with variable demand under partial credit period," *Applied Soft Computing Journal*, vol. 13, no. 1, pp. 428–448, 2013.

[127] K.-J. Chung, "The EOQ model with defective items and partially permissible delay in payments linked to order quantity derived analytically in the supply chain management," *Applied Mathematical Modelling*, vol. 37, no. 4, pp. 2317–2326, 2013.

[128] B. C. Das, B. Das, and S. K. Mondal, "Integrated supply chain model for a deteriorating item with procurement cost dependent credit period," *Computers and Industrial Engineering*, vol. 64, no. 3, pp. 788–796, 2013.

[129] J.-J. Liao, K.-N. Huang, and P.-S. Ting, "A note on inventory ordering policies of delayed deteriorating items under permissible delay in payments," *Journal of Information and Optimization Sciences*, vol. 34, no. 6, pp. 405–416, 2013.

[130] H.-L. Yang and C.-T. Chang, "A two-warehouse partial backlogging inventory model for deteriorating items with permissible delay in payment under inflation," *Applied Mathematical Modelling*, vol. 37, no. 5, pp. 2717–2726, 2013.

[131] H. Feng, J. Li, and D. Zhao, "Retailer's optimal replenishment and payment policies in the EPQ model under cash discount and two-level trade credit policy," *Applied Mathematical Modelling*, vol. 37, no. 5, pp. 3322–3339, 2013.

[132] B. C. Giri and T. Maiti, "Supply chain model with price- and trade credit-sensitive demand under two-level permissible delay in payments," *International Journal of Systems Science*, vol. 44, no. 5, pp. 937–948, 2013.

[133] H. N. Soni, "Optimal replenishment policies for deteriorating items with stock sensitive demand under two-level trade credit and limited capacity," *Applied Mathematical Modelling*, vol. 37, no. 8, pp. 5887–5895, 2013.

[134] A. A. Taleizadeh, D. W. Pentico, M. Saeed Jabalameli, and M. Aryanezhad, "An EOQ model with partial delayed payment and partial backordering," *Omega*, vol. 41, no. 2, pp. 354–368, 2013.

[135] J. C. P. Yu, "A collaborative strategy for deteriorating inventory system with imperfect items and supplier credits," *International Journal of Production Economics*, vol. 143, no. 2, pp. 403–409, 2013.

[136] Y. Zhong and Y. Zhou, "Improving the supply chain's performance through trade credit under inventory-dependent demand and limited storage capacity," *International Journal of Production Economics*, vol. 143, no. 2, pp. 364–370, 2013.

[137] M. Chern, Q. Pan, J. Teng, Y. Chan, and S. Chen, "Stackelberg solution in a vendor-buyer supply chain model with permissible delay in payments," *International Journal of Production Economics*, vol. 144, no. 1, pp. 397–404, 2013.

[138] L. Ouyang and C. Chang, "Optimal production lot with imperfect production process under permissible delay in payments and complete backlogging," *International Journal of Production Economics*, vol. 144, no. 2, pp. 610–617, 2013.

[139] K. Annadurai and R. Uthayakumar, "Two-echelon inventory model for deteriorating items with credit period dependent demand including shortages under trade credit," *Optimization Letters*, vol. 7, no. 6, pp. 1227–1249, 2013.

[140] J.-T. Teng, H.-L. Yang, and M.-S. Chern, "An inventory model for increasing demand under two levels of trade credit linked to order quantity," *Applied Mathematical Modelling*, vol. 37, no. 14-15, pp. 7624–7632, 2013.

[141] S. Khanra, B. Mandal, and B. Sarkar, "An inventory model with time dependent demand and shortages under trade credit policy," *Economic Modelling*, vol. 35, pp. 349–355, 2013.

[142] K.-L. Hou and L.-C. Lin, "Optimal pricing and ordering policies for deteriorating items with multivariate demand under trade credit and inflation," *Opsearch*, vol. 50, no. 3, pp. 404–417, 2013.

[143] R. Uthayakumar and S. Priyan, "Pharmaceutical supply chain and inventory management strategies: optimization for a pharmaceutical company and a hospital," *Operations Research for Health Care*, vol. 2, no. 3, pp. 52–64, 2013.

[144] C.-Y. Chiu, M.-F. Yang, C.-J. Tang, and Y. Lin, "Integrated imperfect production inventory model under permissible delay in payments depending on the order quantity," *Journal of Industrial and Management Optimization*, vol. 9, no. 4, pp. 945–965, 2013.

[145] Y.-F. Huang, W.-K. Chen, H.-F. Chen, and K.-L. Hou, "On the optimal inventory policy for the EPQ model under trade credit," *Journal of Information and Optimization Sciences*, vol. 34, no. 2-3, pp. 187–199, 2013.

[146] L.-Y. Ouyang, C.-T. Yang, Y.-L. Chan, and L. E. Cárdenas-Barrón, "A comprehensive extension of the optimal replenishment decisions under two levels of trade credit policy depending on the order quantity," *Applied Mathematics and Computation*, vol. 224, pp. 268–277, 2013.

[147] H. N. Soni, "Optimal replenishment policies for non-instantaneous deteriorating items with price and stock sensitive demand under permissible delay in payment," *International Journal of Production Economics*, vol. 146, no. 1, pp. 259–268, 2013.

[148] N. H. Shah, D. B. Shah, and D. G. Patel, "Optimal transfer, ordering and payment policies for joint supplier-buyer inventory model with price-sensitive trapezoidal demand and net credit," *International Journal of Systems Science*, 2013.

[149] J. J. Liao, K. J. Chung, and K. N. Huang, "A deterministic inventory model for deteriorating items with two warehouses and trade credit in a supply chain system," *International Journal of Production Economics*, vol. 146, no. 2, pp. 557–565, 2013.

[150] Y. He and H. Huang, "Two-level credit financing for noninstantaneous deterioration items in a supply chain with downstream credit-linked demand," *Discrete Dynamics in Nature and Society*, vol. 2013, Article ID 917958, 22 pages, 2013.

[151] C. J. Chuang, C. H. Ho, L. Y. Ouyang, and C. W. Wu, "An integrated inventory model with order-size-dependent trade credit and quality improvement," *Procedia Computer Science*, vol. 17, pp. 365–372, 2013.

[152] K. R. Lou and L. Wang, "Computers & industrial engineering optimal lot-sizing policy for a manufacturer with defective items in a supply chain with up-stream and down-stream trade credits q," *Computers & Industrial Engineering*, vol. 66, no. 4, pp. 1125–1130, 2013.

[153] K.-J. Chung, S.-D. Lin, and H. M. Srivastava, "The inventory models under conditional trade credit in a supply chain system," *Applied Mathematical Modelling*, vol. 37, no. 24, pp. 10036–10052, 2013.

[154] M. Janková, V. Novotná, and T. Varyšová, "Functions of several variables analysis applied in inventory management," *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, vol. 61, no. 7, pp. 2221–2227, 2013.

[155] S. R. Singh and S. Sharma, "Optimal trade-credit policy for perishable items deeming imperfect production and stock dependent demand," *International Journal of Industrial Engineering Computations*, vol. 5, no. 1, pp. 151–168, 2014.

[156] K. J. Chung, S. D. Lin, and H. M. Srivastava, "The inventory models for deteriorating items in the discounted cash-flows approach under conditional trade credit and cash discount in a supply chain system," *Applied Mathematics & Information Sciences*, vol. 8, no. 5, pp. 2103–2111, 2014.

[157] M. Pal and S. Chandra, "A periodic review inventory model with stock dependent demand, permissible delay in payment and price discount on backorders," *Yugoslav Journal of Operations Research*, vol. 24, no. 1, pp. 99–110, 2014.

[158] C. T. Tung, P. Deng, and J. Chuang, "Note on inventory models with a permissible delay in payments," *Yugoslav Journal of Operations Research*, vol. 24, no. 1, pp. 111–118, 2014.

[159] W.-C. Wang, J.-T. Teng, and K.-R. Lou, "Seller's optimal credit period and cycle time in a supply chain for deteriorating items with maximum lifetime," *European Journal of Operational Research*, vol. 232, no. 2, pp. 315–321, 2014.

[160] Z. Molamohamadi, R. Arshizadeh, and N. Ismail, "An EPQ inventory model with allowable shortages for deteriorating items under trade credit policy," *Discrete Dynamics in Nature and Society*, vol. 2014, Article ID 476085, 10 pages, 2014.

[161] A. K. Bhunia, C. K. Jaggi, A. Sharma, and R. Sharma, "A two-warehouse inventory model for deteriorating items under permissible delay in payment with partial backlogging," *Applied Mathematics and Computation*, vol. 232, pp. 1125–1137, 2014.

[162] L. Moussawi-Haidar, W. Dbouk, M. Y. Jaber, and I. H. Osman, "Coordinating a three-level supply chain with delay in payments and a discounted interest rate," *Computers & Industrial Engineering*, vol. 69, pp. 29–42, 2014.

[163] M. S. Chern, Y. L. Chan, J. T. Teng, and S. K. Goyal, "Nash equilibrium solution in a vendor-buyer supply chain model with permissible delay in payments," *Computers & Industrial Engineering*, vol. 70, pp. 116–123, 2014.

[164] J. J. Liao, K. N. Huang, and P. S. Ting, "Optimal strategy of deteriorating items with capacity constraints under two-levels of trade credit policy," *Applied Mathematics and Computation*, vol. 233, pp. 647–658, 2014.

[165] J. Li, H. Feng, and Y. Zeng, "Inventory games with permissible delay in payments," *European Journal of Operational Research*, vol. 234, no. 3, pp. 694–700, 2014.

[166] S. C. Chen, J. T. Teng, and K. Skouri, "Economic production quantity models for deteriorating items with up-stream full trade credit and down-stream partial trade credit," *International Journal of Production Economics*, 2013.

[167] J. Wu, K. Skouri, J. T. Teng, and L. Y. Ouyang, "A note on 'optimal replenishment policies for non-instantaneous deteriorating items with price and stock sensitive demand under permissible delay in payment'," *International Journal of Production Economics*, 2013.

[168] S. C. Chen and J. T. Teng, "Retailer's optimal ordering policy for deteriorating items with maximum lifetime under supplier's trade credit financing," *Applied Mathematical Modelling*, 2014.

[169] X. Yang and S. Deb, "Cuckoo search via Lévy flights," in *Proceedings of the World Congress on Nature and Biologically Inspired Computing (NABIC '09)*, pp. 210–214, December 2009.

[170] J. Kennedy and R. Eberhart, "Particle swarm optimization," in *Proceedings of the 1995 IEEE International Conference on Neural Networks*, pp. 1942–1948, December 1995.