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# Comparison of four different Inventory Models for Cost Reduction: Takoradi Technical University, Ghana in Perspective

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**ABSTRACT**

*In most organizations, both production and the service industry around the world and likewise Ghana, demand for stock items are mostly uncertain hence makes forecasting quite difficult. This poses a great challenge for officers in charge of stock management to make stock orders in the right quantities and at the right time.*
*In this paper, a model for deciding the best ordering policy to reduce the total stock cost by focusing on the stock management strategies of Takoradi Technical University is presented by the authors. The study discusses a number of models which includes the lot for lot size, economic order quantity, periodic order quantity and the Wagner-Whitin algorithm. The findings reveal that, the overall annual inventory costs for a variety of stock calculated by each method shows that Wagner-Whitin algorithm is the best model for achieving optimum cost at the Takoradi Technical University.*

## 1. Introduction

Effective inventory management in most tertiary institution's supply chains is one of the key elements for success.
The task in managing stock is to balance the supply of stock with demand. In most cases, an institution would ideally prefer to have sufficient inventories to fulfill the demands of its users and not to lose customers or cause employees dissatisfaction due to stock-outs. On the other hand, the institution does not want to have too much inventory in stock due to the cost of carrying inventory. Enough but not too much is the main objective (Coyle and Bardi;Lukinskiy & Lukinskiy, 2017).

Every institutions' fundamental concern is to reduce its total cost for the entire year. Inventory is an important aspect, since it is the stock of any item or useful resource used in an organization.

Tanthatemee and Phruksaphanrat (2012) asserts that stock fulfils many vital roles in an institution and to maintain total costs at the very minimal level should be the major goal. An inventory system is a set of guidelines that controls and keeps stock levels and decides on the time for inventory replenishment, and how massive orders ought to be Jacobs, Chase, and Aquilano (2004).

The inventory value consists of procurement cost, ordering cost, inventory storage fee and shortage costs Gupta and Mohan (2006). Establishing the right quantities to order from suppliers, the organization's productive services also involves a search for the least total cost ensuing from the mixed effect of the four main costs mentioned aboveJacobs et al. (2004). It is the responsibility of stock managers to take vital decision with regards to the balance between replenishment cost and storage cost. If order quantity per unit time is small, the quantity of orders will increase thus resulting in greater ordering cost, even though storage fee is less. Occasionally, this may also result in stock outs. Storage of inventory for a long time might also lead to deficiencies. Thus, a perfect balance between storage expenses and ordering price is very essential. This leads to the development of an efficient inventory model which has the potency to determine a lot size with minimal overall stock cost.

In order to contain cost, inventories need to be reduced without sacrificing the service level to consumers. Inventory management aims at determining and controlling the inventory levels within physical inventory systems, so that the need for stock availability and the need for minimizing the costs related to inventory are well balanced.

## 2. Literature Review

### *2.1 Inventory modeling*

Inventory modeling is concerned with identifying the degree of a product which ought to be kept to make operations easy. The main aim for this resolution is to have a model that balances the cost of capital ensuing from maintaining so much stock in opposition to the penalty cost as a result of stock shortage. The principal thing affecting the answer is thedemand nature, being deterministic or probabilistic.

Inventory Models from a mathematical stock principle perspective, can be categorized into deterministic and probabilistic or stochastic stock models.

### 2.2 Deterministic Inventory Models

A deterministic stock model assumes that the demand is deterministic. Due to this assumption, the evaluation of the model is substantially simplified. Stock out in a deterministic inventory model is normally not allowed. Deterministic inventory models can as well be subdivided into static and dynamic models. In practical situations, the demand sample in a stock model may additionally count on one of the under-listed types:Taha (2011)

Deterministic and static with time.
Deterministic and dynamic with time.
Probabilistic and static with time.

Probabilistic and dynamic with time.

Evolution of lot sizing techniques is essentially primarily based on either heuristic method or mathematical modeling. Economic Order Quantity (EOQ), Periodic Order Quantity (POQ), Lot-For-Lot (LFL) and Part Period Balancing (PPB) are amongst methods that adopted heuristic approach Callarman and Hamrin (1984). Meanwhile, Wagner-Within (WW) model is regarded as a mathematical approach which was developed based on dynamic programming Wagner and Whitin (1958). Evans (1985) in his journal carried out a computer implementation of this model.

#### *2.3 Inventory Models*

Different stock models are viewed at this point with the objective of minimizing overall stock cost.

#### *i. Model 1: Lot for Lot Size*

Jacobs et al. (2004) talk about the fact that, order precisely what is needed for each duration. With this, items are bought in the genuine portions needed for each duration. It sets deliberate orders to precisely fit final requirements. It also produces precisely the requirement needed for every duration with none carried over into similarly periods. It no longer takes into consideration the setup costs or ability limitations. The closing and opening stock is nil as solely required extent is ordered. Thus, the carrying value is nil and the sole costs involved are procurement and ordering cost. However, the ordering exercise has to be executed each time there may be demand for an item. This ends up in high ordering costs. This model is very much appropriate in the case of a huge amount of carrying costs and low ordering costs.

#### *ii. Model 2: Economic order Quantity*

The Economic Order Quantity formulated byHarris (1915) is the order volume which reduces complete stock carrying expenses and ordering charges. This is the most excellent replenishment measurement of stock order that realizes the most fulfilling complete stock value within a given duration of time Sharma (2016). The Economic Order Quantity is applicable in situations where the demand for an item is steady over a period. Also, every fresh order is delivered in full when stock gets to zero. There is a constant fee for every order placed, irrespective of the wide variety of components ordered. There is an additional value for each component kept in storage. Every now and then it is also expressed as a share of the procurement price of the item.

#### iii. Model 3: Period Order Quantity

This model is the Economic Order Quantity which is expressed in periods. The Period Order Quantity is equal to the Economic Order Quantity divided by the average demand per period. The Economic Order Quantity tries to reduce the overall value of ordering and carrying stock, primarily centered on the assumption that demand is constant. Most often demand is not constant, especially in Material Requirements Planning, and the use of the Economic Order Quantity no longer generates a minimal cost. The period order quantity lot-size rule is primarily centered on the same principle as the Economic Order Quantity. It adopts the Economic Order Quantity components to compute an economic time between orders. It is computed by dividing the Economic Order Quantity by way of the demand rate. This generates a time interval of which orders are placed. Instead of ordering the equal extent Economic Order Quantity, orders are positioned to meet requirements for the calculated time interval. The range of orders placed in 12 months is the same for an economic order quantity, whereas the quantity ordered each time varies. Moreover, the ordering cost is the same, but due to the fact that order portions are decided by means of true demand, the carrying value is reduced.

#### *iv. Model 4: Wagner-Whitin Algorithm*

The model is a perfect approach with the aim of identifying the most fulfilling batch measurement for an item with dynamic demand as well as with single stage production, except consideration of capacity constraints.With the traditional lot size approach, which assumes a countless production rate and of a uniform consumption over the duration, the Wagner-Whitin-Algorithm procedure in a forward calculation feasible, picks are recognized after which it is chosen in a backward calculation. The Wagner-Whitin technique produces the most efficient even if fixed charges differ from length to duration. The condition is that the applicable fixed charges are used during the periods.

A vital implication of the Wagner-Whitin- Algorithm is the zero-stock property, where production takes place solely when the storehouse is empty. The most excellent of the entire requirements of a duration is either completely protected from stock or from the production of this period. A scenario is when the demand is partly fulfilled out of manufacturing and partly from the camp, so that it may occur in a length of storage and setup charges may no longer be cost minimal, due to the fact that set up charges can be saved by making progress in the production. An ideal lot consists of continually a total of whole duration requirements. This prevalent discovery was viewed in a heuristic approach to determine the lot measurement as the basis. To discover out the first-class models in the current situation, these fashions are applied to the demand information for 12 months of selected items.

### 2.4 Why stock should be controlled

Stock control therefore, is to have enough quantities of quality objects available to serve customer needs and as well reduce the prices of carrying stock Adeyemi and Salami (2010). Findings by Abanis, Sunday, Burani, and Eliabu (2013)indicate that fine utility of inventory optimization fashions and exercise is applicable to attaining quality and green operations. Furthermore, Adeyemi and Salami (2010) once more found that the common reason of inventory management is to have what is wanted as nicely as to limit the extent of cases relating to production and offerings operations being interrupted as a result of inventory outages. Additionally, Gitau (2016) mentioned that efficient management of inventory has massive potentials for improving organization efficiency and performance. Management of inventories has an important bearing on the economic power and competitiveness of organizations due to the fact that, it directly affects the working capital, production and consumer offerings as well (Gitau, 2016); Vergin (1998). Inventory management practices play a major role inside the operation of many businesses Kimaiyo and Ochiri (2014). Pillai (2010) noted that immoderate inventories tie up working capital and increase up carrying costs.

Moreover, Nyabwanga and Ojera (2012)also asserts that inventory administration practices have come to be recognized as a necessary hassle region wanting top priority. According toKamau and Kagiri (2015), groups have unnoticed the potential financial savings from appropriate inventory management, treating stock as a quintessential evil and no longer as an asset requiring management.

Effective stock administration is critical in the operation of any commercial enterprise Bassin (1990). Onwubolu and Dube (2006)further indicated that, the gain of dividing inventory items into classes permits insurance policies and controls to be installed for every class.

Lastly, powerful stock administration exercise is fundamental internally in the operation of any industrial corporation Mukopi and Iravo (2015).

## 3. Methodology

The study was carried out in one of the technical universities in Ghana which holds and manages a large range of stock which varies over time.

The stock of TTU comprises of lots of items with extensively diverging costs, usage and lead time collectively with procurement and technical issues. It is neither ideal nor feasible to apply the same level of control for all these items. The administration therefore need to pay greater attention to items with high utilization value Gupta and Mohan (2006).

The Always Better Control analysis (ABC) is currently used to categorize all the stock gadgets into three classifications based on their usage values. Items of excessive usage cost but few in terms of variety are categorized as "A" gadgets and would be underneath strict control of top management. "C" objects are large in quantity and however needs a little amount of capital and would also be under simple control. Items with reasonable cost and size are classified under "B" objects and would call for practical interest of the middle degree management.

The ABC evaluation offers a mechanism for determining items that will have a substantial effect on overall stock cost, while also offering a mechanism for figuring out distinctive classes of stock that will require extraordinary management and controls. ABC evaluation of inventory leads to sure advantages in the form of direction to the manager about the stage of manipulation for each kind of item, which are summarized in Table 1.

**Table 1**
**ABC Evaluation of Inventory**

| Activity | Group A | Group B | Group C |
|---|---|---|---|
| Monitoring | Very Strict | Strict | Moderate |
| Safety stock to be kept | Low | Medium | High |
| Level of control for issue | Tight | Moderate | Low |
| Estimates of requirement | Very Accurate | Moderately Accurate | May be low |
| Frequency of Purchase | Most frequent | Less frequent | Least frequent |
| Turn over | Maximum | Medium | Least |
| Management involvement | Top level | Middle level | Lower level |

### *3.1 Categorization of Stock Items at Takoradi Technical University Storehouse*

At the Takoradi Technical University storehouse, stocks have been classified beneath the following headings:

Stationary
General goods
Plumbing items
Electrical items
Building items
Engineering items

### *3.2 Classification of Stock*

The under listed scheme is used in the classification of Stock items under ABC at TTU

- ✓ "A" item – stationary such as toners, "A4" sheets, print cartridges, pens, pencils, erasers, sharpeners, office twine, exercise books, note books, envelopes, staplers, drawing papers, files, stamps and ink pads, paper clips, etc.
- ✓ "B" items – Plumbing items such as flexible tubes, WC handles, valves, PVC pipes, glue, cast iron, galvanized pipes etc.
- ✓ "C" items – Engineering items such as copper pipe, copper rod, hinges, tower bolt etc., Building items such as sandy sealer, putty filler, padlocks, door locks, paints, paint brushes, asbestos etc., Electrical items such as bulbs, socket, cables, capacitors, lawnmowers, shredders, electric switch boards etc., and General goods such as scrubbing brush, toilet rolls, bucket, ceiling brushes, mops, disinfectants, toilet brushes, air fresheners etc.

An evaluation of contemporary year's stock ratio with those of preceding years unfold the following points bearing on to inventories:

*Fast-Moving Items*

This is indicated by excessive stock ratio. This also implies that such items of stock have excessive demand. Obviously, in order to have smooth day to day running of TTU, sufficient inventories of these items must be maintained. Otherwise, both academic and non-academic activities will be adversely affected as a result of uninterrupted supply of these items.

*Slow-Moving Items*

Slow moving items is indicated by a low turnover ratio. These stock items are, therefore, required to be maintained at a minimal level.

*Dormant or Obsolete Items*

These refer to stock having no demand. These items have to be disposed of as early as possible to curb additional losses induced via them.

**4. Data**

The statistics used in this current analysis is outlined in Table 2, which shows the item demands for a period of 12 months at TTU.

**Table 2**
**Demand for a period of 12 months**

| Month | Stationary | Plumbing | Engineering | Building | Electrical | General |
|---|---|---|---|---|---|---|
| January | 246.48 | 177.84 | 94.8 | 149.76 | 252.168 | 786.24 |
| February | 252.72 | 134.52 | 97.2 | 113.28 | 258.552 | 594.72 |
| March | 202.8 | 164.16 | 78 | 138.24 | 207.48 | 725.76 |
| April | 408.72 | 294.12 | 157.2 | 247.68 | 418.152 | 1300.32 |
| May | 416.52 | 372.6 | 106.8 | 220.8 | 284.088 | 1738.8 |
| June | 414.024 | 273.6 | 159.24 | 230.4 | 423.5784 | 1209.6 |
| July | 101.4 | 157.32 | 39 | 132.48 | 103.74 | 695.52 |
| August | 581.568 | 298.68 | 223.68 | 251.52 | 594.9888 | 1320.48 |
| September | 146.328 | 125.4 | 56.28 | 105.6 | 149.7048 | 554.4 |
| October | 419.64 | 310.08 | 161.4 | 261.12 | 429.324 | 1370.88 |
| November | 346.32 | 344.28 | 133.2 | 289.92 | 354.312 | 1522.08 |
| December | 519.48 | 275.4 | 133.2 | 163.2 | 354.312 | 1285.2 |
| **Total Annual Demand** | **4056** | **2928** | **1440** | **2304** | **3830.4** | **13104** |

**Figure 1**
**Item demands for a period of 12 months**

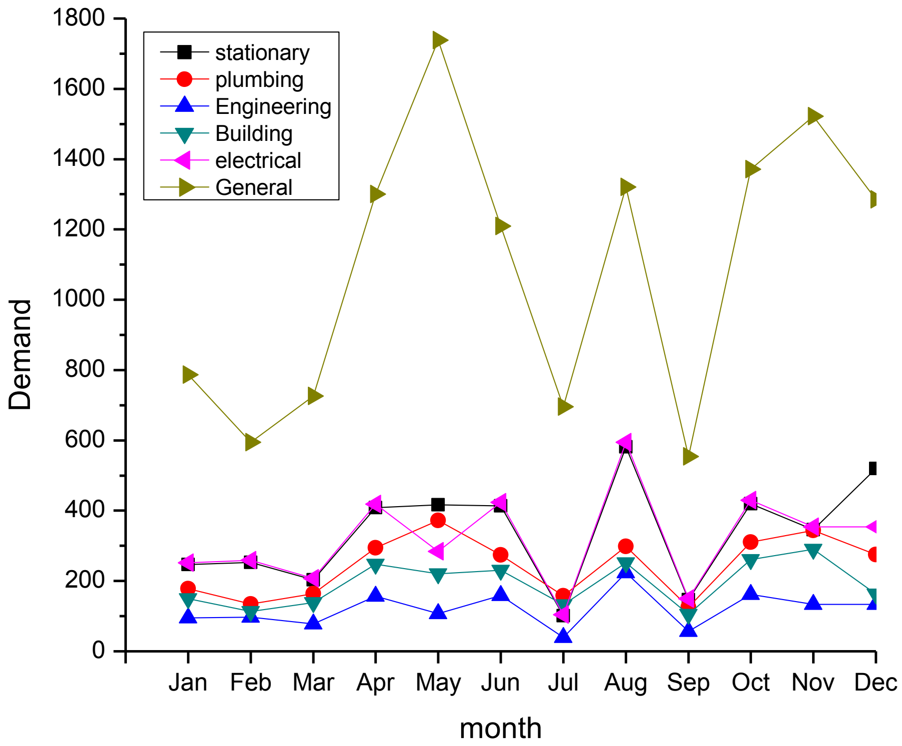


**Table 3**
**Yearly Consumption of each selected item in Ghana Cedis (Gh ¢)**

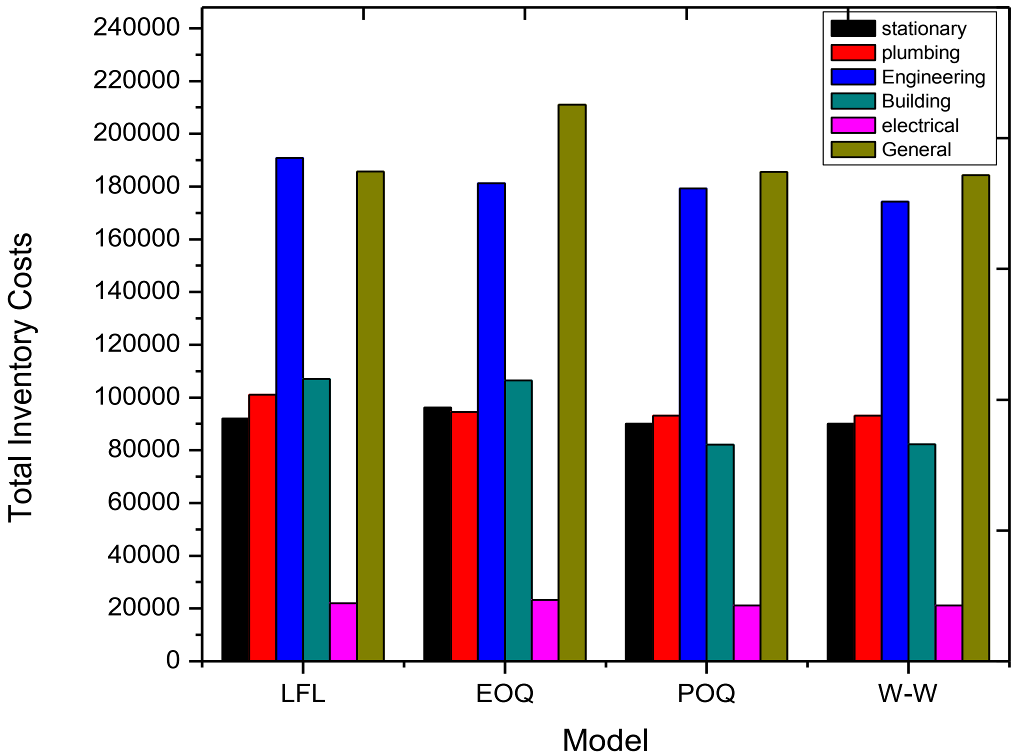
| Component | Unit charge | Yearly consumption |
|---|---|---|
| 1 (Highest Usage Value) | 144.5219167 | 1440 |
| 2 (Lowest Usage Value) | 5.567888471 | 3830.4 |
| 3 (Highest Unit Charge) | 144.5219167 | 1440 |
| 4 (Lowest Unit Charge) | 5.567888471 | 3830.4 |
| 5 (Highest Yearly Consumption) | 14.72027473 | 13104 |
| 6 (Lowest Yearly Consumption) | 144.5219167 | 1440 |

***4.1 Analysis***
***Total Inventory Costs***

**Table 4**
**Total Inventory Costs by Different Models in Ghana Cedis (Gh ¢)**

| Models | Stationary | Plumbing | Engineering | Building | Electrical | General |
|---|---|---|---|---|---|---|
| LFL | 91953.95319 | 101105.8392 | 190823.3529 | 107017.6 | 22012.704 | 185666.4727 |
| EOQ | 96193.81151 | 94499.13915 | 181318.0376 | 106509.4 | 23210.016 | 211047.2 |
| POQ | 90082.87413 | 93089.0427 | 179272.8826 | 82168.82 | 21094.176 | 185583.7455 |
| W-W | 90028.14421 | 93080.94451 | 174272.8826 | 82220.5 | 21094.176 | 184279.9636 |

**Figure 2**
**Total Inventory Costs by Different Models**



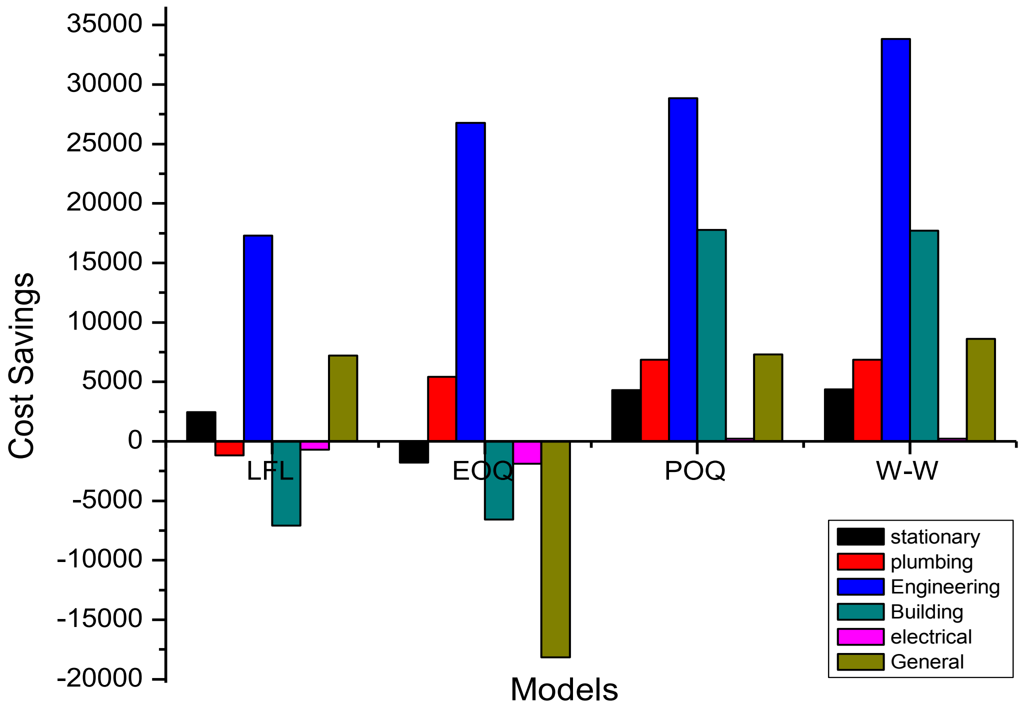

The Wagner-Whitin model gives the minimum complete annual stock value in all cases. Although in each scenario the other models offer minimal cost alongside with the Wagner-Whitin model, non besides Wagner-Whitin model proves to be consistent. However, the Period Order Quantity model offers costs which are closer to the Wagner-Whitin model in almost all the scenarios. It also suggests a minimum share variation from the Wagner-Whitin model. The most frequent model which is the Economic Order Quantity, offers the highest cost.

**Table 5**
**Total Cost Savings by the Different Models in Ghana Cedis (Gh¢)**

| | Stationary | Plumbing | Engineering | Building | Electrical | General | Total savings | Percentage Savings (%) |
|---|---|---|---|---|---|---|---|---|
| LFL | 2454.366806 | -1166.839239 | 17288.20706 | -7069.81 | -685.464 | 7228.007273 | **18048.468** | **2.519** |
| EOQ | -1785.49151 | 5439.860847 | 26793.52241 | -6561.64 | -1882.776 | -18152.72 | **3850.7576** | **0.537** |
| POQ | 4325.44587 | 6849.957303 | 28838.6774 | 17778.94 | 233.064 | 7310.734545 | **65336.817** | **9.117** |
| W-W | 4380.175787 | 6858.055488 | 33838.6774 | 17727.26 | 233.064 | 8614.516364 | **71651.748** | **9.998** |

**Figure 3**
**Saving in Total Annual Inventory Cost**




The whole annual inventory cost acquired by the use of Wagner-Whitin model is termed as a base and a saving in total annual stock value offers an assessment with every model collated. The table above shows the values of savings in whole yearly inventory cost.

### 5. Conclusion

The above discussion surely suggests that the Wagner-Whitin model offers the least overall annual inventory value in all the scenarios per the data obtained from Takoradi Technical University in Ghana. The model has been utilized to the variety of components with very best and lowest yearly usage value, perfect and lowest component price as properly as items with highest and lowest yearly consumption. But in each case used, it was evident that the Wagner-Whitin model shows foremost results. The Periodic Order Quantity model additionally proves to be capable as it suggests very moderate variations from the Wagner-Whitin model. The EOQ and LFL models have greater total annual price with low value financial savings and for that reason will not be suitable to adopt. Other researchers could also conduct further studies with the other inventory models.

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