Origins of economic order quantity formula engineering essay

The Economic Order Quantity (EOQ) is the amount of units that a business should put in to the inventory to reduce the total costs of inventory. For instance, ordering costs, holding costs and shortage costs. The model was developed by F. W. Harris in 1913, but R. H. Wilson, a consultant who applied it extensively, is given credit for his early in-depth analysis of it. The outline used to determine EOQ is known as the Wilson Formula or the Wilson EOQ Model. The EOQ is used to monitor the level of inventory at all times; it can be called as an inventory review system. In addition, a fixed quantity of units is ordered each time the level of inventory gets to a specific reorder point. The EOQ is a model of evaluating the suitable reorder point and the most favorable reorder quantity to ensure the immediate refilling of stock without any shortages. This model is important for small company owners who need to know how much stock to keep, how many units to order when ordering parts, the amount of units to order each time, and frequently to reorder to get the lowest costs. Moreover, ordering a big amount of units a time will increase the holding costs of a small business, while making more often orders of smaller amount of units will decrease the holding costs and increase the order costs. The EOQ model will find the amount to be ordered to minimize these costs and ordering the most cost effective quantity. The EOQ model takes the demand as constant, and the stock is decreased at a fixed rate to reach zero. When the level gets to zero, a particular amount of units and bring the stock level to its initial level.

Other reviews have been discussed in early EOQ papers but much of the history of this model has been left untouched. For example, Raymond 1931, Whitin 1954 and Mennell 1961. All the citations given to Harris's paper was

incorrect, it seems that nobody has been able to find the paper. The inaccurate citation given by Raymond 1931 shows the misplacement of the original model. The first proper citation of Harris's model was by Whitin 1954 who references Harris via a citation given in Raymond's work. A search of the Social Sciences Citation Index from 1966 through 1987 yielded 15 references to Harris's paper, and every citation resembled that given by Raymond.

The variables used in the EOQ formula analysis

The costs of inventory

Reorder cost (RC)

Unit cost (UC)

Holding cost (HC)

Shortage cost (SC)

Demand (D)

Order quantity (Q)

Cycle time (T)

The three steps taken in the derivation of EOQ formula:

First evaluate the total cost of a stock cycle

Then divide the value by the cycle length which will result in cost per unit time.

Minimizing the cost per unit time

Derivation of EOQ formula

Amount of stock entering the cycle = amount of stock leaving the cycle

â†’ Q = D Ã- T

Total cost per cycle = unit cost + reorder cost + holding cost (component)

Total cost per cycle = UC + RC + HC (component)

Now calculate each element of the total cost separately

Unit cost component = Unit cost (UC) Ã- Number of parts ordered (Q)

Unit cost component = UC Ã- Q

Reorder cost component = Reorder cost (RC) Ã- Number of orders made (1)

Reorder cost component = RC

Holding cost component = Holding cost (HC) Ã- Average inventory () Ã- Time taken (T)

Holding cost component =

Now add these components together to get the total cost per cycle:

Total cost per cycle = UC + RC + HC (component)

Total cost per cycle = + RC +

Finding the total cost per cycle is the first step of the derivation. Now divide the total cost by the cycle time (T) to get the total cost per unit time (TC).

Total cost per unit time (TC) = + +

But Q = D Ã- T

â†’ D = or T =

Substituting this in the total cost per unit time (TC)

Total cost per unit time (TC) = UC Ã- D + +

The third step is to minimize the total cost per unit time. The derivative of the total cost per unit time (TC) with respect to Q and make the result equal to zero.

= - + = 0

â†’ =

â†’ =

â†’ EOQ =

Limitations to EOQ Formula

Assumes that ordering and carrying costs are accurately known.

It takes the Storage space as unlimited.

Ignores the delivery quantities and discounts given.

Assumes that the seller controls the delivery scheduling.

The results are always carrying a number of stocks.

Cost structures have changed. For instance, the ordering costs have been decreased by e-commerce.

Part b

The literature on using economic order quantity (EOQ) and just-in-time (JIT) purchasing have chosen JIT in the last few years, in particular when companies are purchasing to meet high and constant levels of demand, where the JIT method have the advantage of reducing the inventory space (Per square meter) of the firm. On the other hand, even if JIT method can reduce the inventory space of the company, EOQ can be more cost effective. Mainly, JIT is used when the ratio of holding costs to ordering costs becomes so high that it becomes valuable to order as needed. This happens if the holding costs of inventory are high (Computer industry) that the ratio becomes high which leads to the use of JIT. In addition, when the ordering costs is cheap which results in high ratio and the use of JIT is more efficient. In both cases the EOQ makes companies use JIT since the quantity that is most cost-effective is so little that money savings can be achieved by ordering small batches using JIT method. The implementation of JIT method have improved many firms that still use EOQ purchasing system to consider switching to JIT purchasing method.

Just-in-time method

JIT (also known as stockless production or lean production) means producing only what is needed, when is needed and in the amount is needed. JIT companies store only enough stock to manufacture the goods they want to

produce in the near future. Units are ordered on a continuous basis, which are transferred straight into the assembly line. The benefits of JIT method is to reduce inventory levels, reduced leadtime, improve quality and reduced waste and rework. The main objective of this method is to eliminate waste and continuous improvement of productivity. Waste outcome as a result from any activity which adds cost without increasing value. JIT purchasing of parts is completely different than traditional purchasing of parts. Traditional purchasing is by spreading purchases around and trying to maintain a high level of inventory in case of any rise in demand or quality of supplier decreased unexpectedly. However, JIT purchasing enables the supplier to deliver high quality products depending on demand and in a timely fashion. Quality is hardest standard for suppliers to meet, where the JIT purchaser should deal with companies that give statistical analysis to confirm the high quality of products. On the other hand, for the supplier to produce on-time deliveries, it is easier for the supplier to be in the same geographic region as the customer. In this way the supplier can easily react to any unexpected change in demand and it costs less to make frequent deliveries if required.

JIT operates on 3 things:

Continuous flow

Takt time

Pull system

Takt time is the time to produce a single component or entire product, based on sales. In other words it sets the speed of production to meet the speed of sales.

The kanban or " pull" system is a method to manage the just-in-time production process. The just-in-time method is achieved using kanban system. It is an information system to control the production amount in each process. The following processes go to preceding processes and take what is needed. However, preceding processes must restock what is taken away.

Figure 2 (Kanban system)

There are 2 main types of kanban system (shown in figure 2):

Production kanban: Signals to produce more components.

Withdrawal kanban (move kanban): Signals to take components from one work center and send them to the next work center.

Advantages of JIT method

The quality of products is improved.

Quality is the responsibility of all the staff not only the quality control workers.

Cycle times are reduced.

Scrap and rework are reduced.

Set up times are decreased.

Cost savings.

Less inventory level of raw materials and finished goods which decrease cost of holding them.

More skilled workers who are able to switch tasks.

Productivity is increased.

Higher workers involvement

Less space requirements

Smoother production flow

Better relationships with suppliers.

Benefits of using the kanban system:

Better managed inventory levels: Having too much inventory levels can cause cash flow problems by increasing the expenses on insurance, storage and security. The kanban system eliminates all these costs by lowering the level of inventory.

Smoother manufacturing flow: The kanban system focuses on the current condition of the system. The production levels are determined to take into account scrap, downtime and the change of equipment overtime to make sure that the production schedule is achieved.

Overproduction elimination: kanban is less expected to cause overproduction this because the need to make buffer inventory to address unexpected delays.

Decreasing the risk of Inventory obsolescence: Products have a shelf life where it can expire if it is not delivered on time.

Responsiveness to demand: One of the main advantages of kanban system is that it improves responsiveness in relationship to change in demand.

Empowerment: Another advantage of kanban system that it places the control in the hands of workers that can view the production process. Empowerment is an efficient managerial tool which reinforces training and education among employees.

Quality control and self discipline: The last advantage to kanban system is its purpose to create an environment with quality management. Kanban system uses small lot sizes which allow quality control issues to be pointed at the source.

All in all, the concept of JIT is not only everything must be done fast, but the most significant thing is that the company have an organized resource allocation. It is true that the implementation on JIT is expensive process, but the company can solve its problems and difficulties to achieve high levels of workflow. EOQ system is better for larger companies where the inventory ordering cost can't be split. However, smaller and medium size companies it is better to use JIT system. In other words, JIT system is more advantageous than EOQ for companies whose annual demand levels are low. EOQ can be

one of the tools used to achieve JIT method. EOQ is used to find out which elements fit into JIT model and which level of JIT is economically beneficial for the company.

Question 2

Introduction

It is quite exceptional for an accident to be related to one single cause. Almost every disaster is the consequence of a chain of events and accident reports usually make a distinction between the main cause and a number of contributing factors.

The main root cause is human factors. In order to prevent this source of accidents, the workers are requested to regularly train. Next comes the aircraft failures, but this cause is less likely to happen with modern aircrafts.

Human factors included 12 as the most critical factors leading to accidents:

Lack of communication

Complacency

Lack of knowledge

Lack of assertiveness

Lack of team work

Distractions

Fatigue

Lack of resources

Pressure

Stress

Lack of awareness

Norms

The circumstances of the accident discussed are caused by plenty of the human factors mentioned above.

Brief of the accident

The March 27, 1977, a disaster happened at Tenerife were two 747's were destroyed leaving the highest number of airliner passenger fatalities. The accident killed 583 people when a KLM Boeing 747 was trying to take-off which collided with another 747 for the Pan Am airlines at the Los Rodeos airport.

This accident remains the deadliest disaster in aviation history with 583 fatalities. The KLM Flight 4805 was fully-fuelled and had 248 aboard who were all killed in this accident. On the other hand, the Pan Am Flight 1736 had 335 deaths and 61 survivors, which was hit along its backbone by the KLM's landing gear, 4 engines and the under belly of the aircraft. Because of the heavy fog and the division of the damaged aircraft after collision, the rescue crew didn't know over 20 minutes that the Pan Am aircraft was involved in the collision.

Later investigations show that there were many factors lead to this disaster:

Pilot error

Air Traffic Control error

Communications difficulty

Fog, and airfield obstruction where diversion of air traffic to Los Rodeos airport because of a bombing and a threat for another bomb in another airport which lead to shut the airport.

All of the mentioned reasons or can be called as the key factors contributed to this catastrophe.

Disaster Events and Related Human Factors

For both planes, Tenerife was an unscheduled stop, and the whole events started with a terrorist bomb planted at Las Palmas airport.

Bombing at Las Palmas (Caused distraction and pressure)

All the occasions of both planes was routine until they reached the islands, where the civil aviation authorities shut the airport because of a bomb explosion and diverted all the flights to Los Rodeos airport, as well as the 2 Boeing 747 aircraft which took part in this accident.

When the Pan Am Flight contacted the Gran Canaria airport, it was notified of the temporary closure. Even though the Pam Am aircraft's crew said that they would like to move around the airport in a holding pattern until the

airport give them the landing clearance, the aircraft was ordered to switch to Los Rodeos airport, the same as the KLM aircraft.

The bomb explosion at the airport caused distraction and pressure and this is concluded because the air traffic controllers were forcing the Pan AM crew to divert to Los Rodeos airport without realizing that there will be two large B747 together with some other aircrafts at a small airport having small and close taxi ways and this lead to the second event.

Congestion at Los Rodeos (lack of resources)

It was known that Los Rodeos airport is small to accommodate large aircrafts and even though the air traffic controllers were forcing all the aircrafts to divert there.

At least five large aircrafts changed direction to Los Rodeos airport. The airport had one runway and one taxiway which are parallel to each other; also it has few taxiways which connect the runway with the main taxiway. During the period of waiting for the Gran Canaria airport to open, the aircrafts occupied so much space which were parked on the main taxiway, which means that the taxiway can't be used for taxiing anymore. Instead, all the departing aircrafts would taxi on the runway and position themselves for takeoff, which is known as runway backtrack.

Refuelling (Lack of Knowledge from the KLM Captain)

The Pan Am Captain had decided to fully refuel at Los Rodeos instead of Las Palmas, apparently to save time, but by doing so he added extra weight, greatly retarding liftoff (and accident escape) ability, which proved fatal.

After the bomb threat at Gran Canaria Airport had been controlled, civil aviation authorities reopened the airport. The Pan Am aircraft was all set for take-off, but it was obstructed by the KLM aircraft and a refuelling vehicle and couldn't reach the runway. Due to lack of clearance, the Pan Am couldn't maneuver around the KLM aircraft to each the runway and take-off.

Taxiing and weather conditions

In this event there were more than one factor involved. Started with complacency from the KLM crew concluded from the following events.

Subsequent to the tower's instructions, the KLM aircraft was cleared to backtaxi and prepare the aircraft for take-off position; which was a hard maneuver to complete with a small runway. During the backtaxiing of the KLM aircraft, the ATC controller asked the aircraft's crew to report when it was all set to copy the ATC clearance. Since the crew was completing the checklist, copying of the ATC clearance delayed until the aircraft was already in take-off position. During taxiing, the weather conditions got worse where low clouds and fog limited the visual range.

Lack of communication

The lack of communication occurred between the Pan Am crew and the ATC to start taxiing and this showed when the Pan Am aircraft was instructed to also backtaxi, to follow the KLM aircraft down the same runway, and then leave the runway by taking the " third exit" on the left of the aircraft and then using the main taxiway parallel to the runway. Firstly, the Pan Am aircraft crew was unclear as to whether the controller had told them to leave from the first or third exit. For this reason, the crew requested for

clarification where the controller replied by saying: " The third one, sir; one, two, three; third, third one". The aircraft started to taxi and carried on to recognize the unmarked taxiways using an airport diagram as they reached them.

Based on the use of the cockpit voice recorder and the space between the taxiways and the position of the aircraft at the moment of collision, the crew successfully identified taxiways number 1 and 2, but according to the discussion in the cockpit they had not seen the third taxiway, which they had been told to take, and this is obvious that there were again a lack of resources inside the airport because it appears that there were no markings or signs to identify the runway exits. And this is followed by another factor which is lack of awareness from the Pan Am crew who were taxiing at a very slow speed because they were appeared to remain unsure of their position on the runway until the collision.

Based on an official report from the Spanish authorities appears that there was a lack of knowledge from the ATC who could not explain why the controller had instructed the Pan Am aircraft to use the third taxiway, rather than the sensible and easier fourth taxiway.

Communication misunderstandings (lack of communication)

The event briefed below shows a lack of communication between the KLM crew and the ATC and this was almost the turn point of the accident.

Straight away after lining up, the KLM captain advanced the throttles which is known as " spin-up", this is done to confirm that the engines are functioning correctly for takeoff. The co-pilot was shocked by the maneuver,

rapidly advised the captain that ATC clearance was not given it. Captain responded, " I know that. Go ahead, ask." After that the co-pilot then contacted the tower that the aircraft is " ready for takeoff" and " waiting for our ATC clearance". Due to this, the KLM crew then got instructions which stated the route that the aircraft was to take after takeoff. The instructions given used the word " takeoff," but did not contain a clear statement saying that the aircraft is clear to take off.

The co-pilot read the flight clearance back to the controller, finishing the readback with a statement saying " we're now at takeoff", showing the controller that the aircraft was beginning the takeoff roll. The captain disrupted the co-pilot's readback with the comment " We're going". As seen here, the co-pilot chose not to embarrass his superior (the pilot) a second time by saying that the aircraft did not have the proper clearance to take off, which created a new factor which is a lack of assertiveness, since the co-pilot failed to express his opinion and failed to take a forceful stand on the issue.

The Collision

After spotting the landing gear lights of the KLM aircraft, the Pan Am crew applied full power and took a sharp turn to the left towards the exit to avoid the collision. The KLM captain also attempted to avoid collision by climbing away which scrapped the tail along the runway for 20 meters. As the KLM aircraft left the ground, its steep angle of attack allowed the nose gear not to hit the Pan Am aircraft. But the lower fuselage and the main landing gear of KLM's aircraft hit the upper side of the Pan Am's fuselage which ripped it apart directly above the wing. In addition, the right engines of KLM's aircraft hit the Pan AM'S passenger cabin behind the cockpit. Due to the thick fog,

the firefighters were unaware of the 2 aircrafts involved in this accident focusing on the KLM wreck.

Conclusion

The culture of the organization can be described as 'the things we do things here'. It is a group or company norm.

Ultimately, safety culture is an amalgamation of the attitude, beliefs and actions of all the individuals working for the organization and each person should take responsibility for their own contribution towards this culture, ensuring that it is a positive contribution rather than a negative one.

Avoiding such an accident in the future can be done by avoiding human factors and this will require a lot of cautious and following of procedures under the flag of safety first.

Suggestions to avoid accidents or any type of incidents can be given based on the human factors mentioned before:

Discuss work before and after completion.

Use effective communication.

Never work from memory, use procedures no matter how often you performed the task.

Understand what are you doing and use updated references.

Express your opinion and disagree with opposite.

Take a forceful stand on an issue without being abusive.

Don't compromise your standards and when in doubt ask questions.

Function smoothly and have a good relation with your team.

Do not work under fatigue and have another colleague to check your work.

Use the right references, equipments and tools.

Know your limits and be assertive.

Learn when to say NO.

Exercise and sleep regularly.