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SUITABLE INVENTORY MODEL FOR AUTOMOTIVE MANUFACTURERS AND MESURES TO MITIGATE THE IMPACT OF THE CRISIS ON PURCHASING LOGISTICS IN TIMES OF CRISIS

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Abstract:

The aim of this work is to choose a suitable inventory model for automotive manufacturers and based on research to define how to manage a purchase logistics in time of crisis and what to focus on. There is described purchase logistic processes with respect to crisis time in first theoretical part. There is also described types of stock and than inventory models are evaluated and assessed suitability with respect to companies operating in automotive industry. One model is then applied to companies which provided data during the research and than a suitability is verified. The paper then describes a metodology of research, a case study with metodology which deals with practical knowledge of companies operating in automotive industry in time of economic crisis in 2008 -2010. Based on practical knowledge at the end are defined measures to how to face the crises in purchase logistics.

Key words:

Economic crisis, Purchase logistics, Stock, Inventory, inventory Models, case Study.

***JEL*:** L20, L62, M1

1 Introduction

The aim is to choose a suitable inventory model for automotive companies and based on the case study to define how to manage a purchase logistics in time of crisis. There are described theories of stocks taking into account the economic crisis. One model is then applied to the example of small busineses operating in the automotive industry, which is facing lack of orders caused by the crisis. The main goal is to make relevant case study to understand possible impacts of crisis and to define steps and mesures to mitigate the impact of the crisis on Purchase logistics. The paper also focuses on one of most important thing to be solved during the economic crisis - stock.

The majority of manufacturing companies have considerable storage costs and try to continuously optimize an inventory management. This effort is even more important in a period of economic crisis. The economic crisis came in 2008 after long period of economical growth and managements of production companies have taken many steps to avoid the impacts of the economic crisis. For example in the automotive industry the economic crisis started almost immediately. Consumers have begun to restrict the buying of things which are not necessary and cars are this kind of goods. There were estimates that the production capacity of cars in Europe was higher by 20% than real demand since the beggining of the century. This means that the automotive sector has been strongly hit by the economic crisis (Biesebroeck, 2010).While the 2008 customer requests continuously grew, 2008 began to fall. Macurová (2011) states that manufacturers in survey of risk factors say that the biggest problem is a decline in orders.

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2 Definition of logistics, purchasing and purchasing logistics, position in organizational structure

2.1 Logistics

There are many definitions of logistics. Simple definition says it is the need to have everything at the right time at the right place. More complex definition explains logistics as a system that includes planning, flow management and storage of goods, services and information from point of origin to the point of production in order to satisfy the customer. In this work it deals primarily with manufacturing logistics, which includes mainly distribution, order processing, production management, purchasing and storage.

2.2 Purchasing

Lukoszová (1999) stated that the main task of purchasing is to ensure trouble-free production operations and non-manufacturing processes in company. In the comprehensive definition then Lukoszová (1999) states that the basic function of the purchase department is to ensure efficiently primary and auxiliary services and non-production processes by raw materials and products in the required quantity, range, quality, time and place.

2.3 Purchase logistics

Purchase Logistics ensures the fluent running of all processes in the company by providing necessary inputs which are directly linked to production processes. Purchase logistics is part of the Purchase or belongs to a segment of logistics or there is a kind of intersection of these segments in matrix structures. In most of today's enterprises the purchase logistics is an integral part of logistical material and information flows that work across the entire company and are connected to other parts in the logistics chain. *Regardless of whether the purchase logistics is associated with purchasing or logistics mainly includes the following activities: taking orders, shipping, receipt goods, storage, input material and inventory management* (Tomek and Hofman, 1999).

3 Purchase logistics in time of economic crisis

As mentioned earlier a purchase logistics includes mainly the following activities: taking orders, shipping, receiving, storage, material receipt and inventory management. These individual actions will be discussed with respect to crisis.

3.1 Orders and economic crisis

Two situations may mainly occur in handling orders during the economic crisis - customer call offs fell sharply or the supplier of stricken crisis is unable to supply the requested order. In the first case it is absolutely necessary to react quickly and to project a reduction in customer orders to suppliers and cut them down immediately. If it is not done in time, an excessive warehouse stock threatens, which binds funds needed especially in economic crisis. In the latter case, because of the economic crisis existing supplier is not able to meet its commitments and not being able to fulfill orders. Then it needs to reduce orders for the strict minimum necessary and increase their frequency.

3.2 Economic crisis and transport

In times of economic crisis more than ever it is necessary that transport works without fluctuations exactly as required by the purchase logistics. During the crisis there is often a need to use special transports, which, however, total logistics costs increase. As occurred in the crisis period after 2008 to a decline in orders that transportation volumes decclined too. Carriers had to reduce its fleet of vehicles, some smaller carriers have been forced to close down. Although the retreat of the crisis was very slow, carriers were often unable to face growing requirements for transporting. Indeed, caution still prevailed, and they did not want to expand fleets.

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3.3 Material recept and crisis

The impact of economic crisis on the receiving material does not appear to be critical. Generaly, if the supplier in crisis is unable to deliver the goods on time and in sufficient quantities, the company may in the context of the need to accelerate the receipt of goods to simplify the incoming procedure. Conversely, if the supplier has troubles with the quality, each incoming piece will be inspected carefully and the entire receiving process will be prolonged.

3.4 Economic crisis and storage

In the event of economic crisis is the need to check the warehouse processes constantly, as well as to stabilize and to improve. A frequent consequence of the crisis is a drope in orders which may manifest as a reduction of staff in the warehouse. This makes it harder to retain and then additionally improve logistics processes with fewer workers. For inventory management following indicators are often used: stock level, inventory turnover and inventory turnover time.

Inventory turnover is an important indicator that expresses how many times a certain period average stock is consumed or reversed. *Inventory turnover time* is equal to the average of the stocks multiplied by the number of days which is than divided by total output (sales) in the period. The figure indicates for how many days of requirements existing stocks are available. Inventory turnover time or stock level are often defined among Business Scorecard indicators, a tool to control the company. Purchase or logistic managers are often evaluated based on the values of these two indicators. Stock

As already mentioned, companies have in their stocks bounded significant material assets and therefore seek to optimize them. Stocks can be classified according to different criteria - according to the degree of processing, according to the purpose or function.

3.5 Types of stock

According to function stocks are devided as follows:

- Disconnect stocks:
  - turnover (common) stocks – reserve to cover needs between two deliveries,
  - safety stock – reserve to cover random fluctuations,
  - anticipatory stocks (frontloading) – for example stocks in case of seasonality,
  - stocks in the logistic channel – transport stocks, material in the progress.
- strategic reserves – reserves in case of unforeseen events,
- spekulative stocks – stocks purchased for some occation, mostly during the anticipated growth of input prices,
- technologic stocks – stocks for supplies of technologic needs (food industry),
- stocks without function.

As already mentioned companies have in their stocks bound substantial assets and therefore seek to optimize them. Stocks can be classified according to different criteria - the degree of processing, according to the purpose or function.

Based on experience in logistics there will be mentioned some interesting things related to stocks. There are strategic reserves which French carmakers PSA (Peugeot-Citroen) and Renault required to be in the contract. The supplier was required to hold in an external warehouse a three-day supply of finished products in case of unforeseen events. An example of unforeseen events given was a fire or strike. This was probably due to past - experience of the workforce going on strike in France. It was necessary to restructure once a year those finished products and they had come to the customer specially marked, therefore it was not necessary to continuously permit based on FI-FO (First In = First Out).

It is also possible to mention of practical experience some of the stocks that fall into the category of stocks without function. In practice it is hard to not meet with the company where they should not have stocks belonging to the category of unwanted. For example a customer has announced

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that one of the final products will want a certain amount per year. However the marginal model did not sell as predicted and forecasts at once rapidly decreased. The logistics individual responsible for this did not respond properly and not did not promptly cut call offs to the supplier. The supplier produced originally ordered components and delivered and the customer had stocks for several years.

In every company there will be plenty of finished products, semi-finished material or input components and raw materials which are either mostly refused for qualitative reasons by the customer or the company itself is trying to claim against the suppliers. For example, this includes products that are out of tolerance of the customer and the company itself picked this up during the Goods In examination. Due to complicated negotiations about guilt, exceptions and acceptance with customers and suppliers these stocks are in store for many months, sometimes years, and finally, the company is often forced to destroy the goods.

In the automotive industry suppliers agree to supply products throughout the entire life cycle of a specific car model and also undertake a period of time to deliver products even after production of spare parts. This often means having enough stock input materials or finished products to be produced in a cost-effective batch for several years.

3.6 Inventory cost

From a financial and economic point of view costs are associated with inventory because stocks are bound resources that could be used in another way.

Costs connected with stocks:

- costs for orders,
- costs connected with stockholding,
- costs for lack of stocks.

More detailed will be mentioned costs resulting from deficiency reserves, which are the nightmare of all companies operating in the supply chain of the final car manufacturer. Thanks to the considerable competitive environment, mentioned the economic crisis, the enormous pressure automakers and sometimes due to a false sense of infallibility and sophistication of management tools in the automotive industry suppliers sometimes compress their inventory to an absolute minimum. Then whatever the reason may be that the products to the customer are not at the moment available.

Companies supplying parts to car manufacturers are well aware that stopping the production line automaker is extremely expensive, because for every minute they are charged a fine of several million crowns. Among the suppliers in the automotive industry circulate various stories about flying a helicopter to the car factory with several components as a carmaker forced a small carrier to stop their business because his truck crashed with key supplies and threatened production.

3.7 Stock models

Stock models try to answer the question when to order a new delivery and how big should be the delivery. Company leaders often try to find out an optimal level of stocks. Stocks models theory can be classified according to various criteria. One of the fundamental division is cutting stocks models for *deterministic* and *stochastic* models. The models are divided according to the exact nature of the demand. Deterministic models assume that the demand at the time is fixed. Stochastic models assume an unlimited demand - demand size is fixed only with a certain probability.

3.7.1 Deterministic stocks models

If we know in advance the size needs to be met from stock and is not necessary to calculate with fluctuations, it seems pointless to create any safety stock. Therefore all deterministic models optimize only reversing component inventory and optimum cost is expressed only by the storage costs and recurring costs replenishment.

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EOQ model – optimum size delivery

As stated JABLONSKÝ (2007), EOQ model (economic order quantity) is essential, probably the oldest and most famous model, where demand is continuous and does not change over time. In the literature we can meet with the name Harris-Wilson model. It is based on the following assumptions:

- reserves are supplemented at one time after their exhaustion,
- there is no shortage of reserves (at the time exhaustion warehouse is completed),
- the acquisition period of deliveries is known and constant,
- demand is known ahead for the item purchased for the entire supply period,
- size of all deliveries is constant,
- due to constant demand stock consumption is uniform,
- purchace price is independent of the size supply.

There is regular repetition of supplies in this model that are identical. The total cost of replenishment warehouse can be expressed as follows:

$$N(q) = c_1 \frac{q}{2} + c_2 \frac{Q}{q} \qquad (1)$$

where

c_1 is an annual unit cost of storage
c_2 is an acquisition cost per delivery
q is a size of one delivery
Q is a size of year demand
$q/2$ is an average stock size
Q/q is a number of delivery cycles

We can influence the level of cost in formula (1) only by the size of delivery q, which is the only variable in this model.

Under these assumptions it is possible to determine how large is the supply and how often should a company to order an item that costs associated with acquiring and maintaining inventories as low as possible. If we put the first derivative of the function $N(q)$ is zero:

$$\frac{dN}{dq} = \frac{c_1}{2} - \frac{c_2 Q}{q^2} = 0$$

and we solve this equation for the unknown q then as a result we get:

$$q^* = \sqrt{\frac{2Qc_2}{c_1}}$$

Thus will be calculated in this model optimum delivery .

If we substitute the optimal value to the cost function (1), after treatment a total optimal cost is

$$N^* = \sqrt{2Qc_1c_2}$$

Than we can express optimal replenisment cycle lenght t^*:

$$t^* = \frac{q^*}{Q} = \sqrt{\frac{2c_2}{Qc_1}}$$

As mentioned above, this model is historically one of the oldest and stands on several assumptions, which are difficult in the real world securable. On the other hand all the stakeholders in the

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automotive industry tries to set up and develop such complex processes throughout the supply chain, which could make orders the entire system of orders as simple as possible, more transparent and fixed. For some simpler calculations the theoretical conditions of this model could be used, however, in the automotive industry hit by crisis cannot be apply several conditions of the model (size of delivery is the constant, supplement the storage occurs at any one time, utilization of inventory is uniform).

Transitional dissatisfaction demand model

This model differs from the previous model only in that it allows a temporary shortage of stock in the warehouse. Therefore the demand may be unsatisfied for a transitional period. This brings additional costs. The principle of the model, namely that there is a temporary unsatisfied demand, is unacceptable in a particular case of the company in the automotive industry. Therefore that will not be considered for the calculation model.

POQ Production model

A production model POQ (production order Quantity) again using the same assumptions as the EOQ model. The difference is that it does not apply one of its conditions - the supplement of the storage occurs at one time. Adding storage is not disposable. The delivery cycle is divided into two – production and consumption cycle. This model is closer to reality, but still there are assumptions that the size of the supply is constant and utilization of inventory is uniform. However the projections in the supply chain in the automotive industry do not apply and therefore even this model will not be considered for calculation.

Rebates model

Here we will briefly mention a rebates model which however in the automotive industry is considered too inappropriate. It does not apply here as one of the assumptions in the model EOQ that the purchase price does not depend on the size of the order. In this model we assume that the supplier offers quantity discounts.

3.7.2 Stochastic stocks models

One of the assumtions in previous deterministic models was evenly distributed demand. Stochastic models are models with uncertain demand. We often assume a normal distribution in stochastic models, which describes well the course uncertain demand.

Stochastic continuous demand model

It continuously monitors the status of stocks in this model, which means that a new order is issued at a time when the total inventory in the warehouse drops to a specified limit. This limit *r* is called a point of another order. The acquisition period *d* is constant.

As stated JABLONSKÝ (2007), during the acquisition lead times may occur 2 cases:

1. Demand during acquisition lead times *d* is lower than the point of another order *r.* Another delivery arrives at the warehouse even at time when there is some stock in a store. This means that the stock is continuously available and no unsatisfied requests – see the first cycle in fig. 6,
2. Demand during the acquisition lead times *d* is higher than the point of another order *r.* In this case the consumtion of stocks will come during acquisition time delivery and not to the full satisfaction of the requirements - see the second cycle in fig. 3. Points R1 and R2 show the exposure order.

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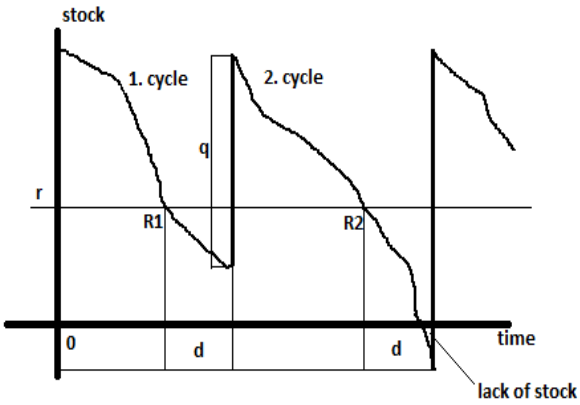
Figure 3 Dependence of stocks at the time when the stochastic demand



Source: *JABLONSKÝ J. (2007).* Modely řízení zásob*, Operační výzkum.* Praha: Professional publishing, p. 228

It is necessary to know the character of stochastic demand when creating stochastic models. This is determined by the appropriate probability distribution, its mean value μ_Q and by standart deviation σ_Q. The mean value and the standart deviation of demand during acquisition lead time *d* will $\mu_d = d\mu_Q$ and $\sigma_d = \sigma_Q$

We will assume that the demand will be during the acquisition lead times a normal distribution with mean value μ_d and standart deviation σ_d.

Another assumption that occurs is the *level of service*. It is a probability that within one delivery cycle are not unsatisfied requests. The level of service we denote γ. When the demand will be lower than the point of a new order *r* *, there is no unsatisfied demand. Otherwise when the demand will be higher than *r* *, occurs unsatisfied demand. If a company wants to reduce the probability of unsatisfied demands and to increase the level of service, it must issue an order at the moment when the supply drops to a level which is still higher than *r**. Then will apply:

$$r_\gamma = r^* + w,$$

When *r** is point of furhter order, r_γ is point of further order for a given level of servis and *w* represents a *safety stock.* It is an additional supply that allows to cover excess demand during the acquisition lead times. Safety stock leads to a higher level of service, but also causes higher storage inventory costs. JABLONSKÝ (2007) stated, that a mean of storage and cost enumerate:

$$\mu_N = \sqrt{2\mu_Q c_1 c_2} + c_1 w$$

To determine the amount of safety stock is needed to solve:

$$P\{Qd \le r^* + w\} \ge \gamma \ ,$$

where *Qd* is a demand during the acquisition period and P is the probability, that the actual demand is lower than the level of orders totaled more with safety stock, which should be higher than γ. It is now necessary to define the probability distribution of the demand, which is, as mentioned above, the normal distribution. Given that in the tables are only available values of the distribution function of the standard normal distribution *N (0,1)* it is necessary to transfer random variable *Qd* with distribution $N(\mu_d,\sigma_d) = N(r^*,\sigma_d)$ to random variable with distribution *N (0,1)* according to

$$z = \frac{Qd - r^*}{\sigma_d} \qquad (2)$$

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value z_γ, which correspond to level of service γ , we determine from the table of the distribution function of the distribution *N (0,1),* where for exemple where in

γ = 0,99 is $z_{0,99}$ = 2,327

After substituting into *(2)* we get

$$Qd = z_\gamma + r^* \qquad (3)$$

When creating safety stock must pay

$$r^* = w \geq Qd^* \qquad (4)$$

After combination *(3)* and *(4)* we get

$$w \geq z_\gamma \sigma_d$$

Safety stock must be created at such level to pay this formula.

The stochastic model of continuous demand will be used to determine optimal inventory and safety stock for a specific example of company operating in the automotive industry. Shortly there will be further mentioned stochastic model, which is a single inventory optimization model, but in our particular case is not applicable because a larger supply is created at the beginning which than no longer supplemented as in the automotive industry not used practically.

Model created a singl stock

As mentioned above, once is created the stock at the beginning and gain no longer. Demand is not deterministic, it is then necessary to describe it by some probability distribution. This model is used primarily by the demand for goods seasonal nature (eg. Christmas trees) for perishable goods (fruits, flowers). A typical role model is called a newsboy problem, the problem of newspaper dealer. It means that the standard deviation and the mean demand is estimated based on previous experience.

3.7.3 Other stochastic models

Professional literature (Liu 1999, Browne 1991) provides some further modifications of stochastic models. One of them is a stochastic model based on a deterministic model EOQ transactional dissatisfaction with temporary demand. The calculation procedure is the same as for the continuous stochastic demand coming from the basic EOQ model, it only works here with that dissatisfaction demand. Other stochastic models (Lukáš 2012) are models, that unlike all previous stochastic models that work with continuous knowledge of the stock, determine stock levels only for a certain period. Those are stochastic two-period models with no setup cost and stochastic multiperiod models with no setup cost. These models (Simchi-Levi 2002) are very complex and given that the vast majority of companies operating in the automotive industry has its own warehouse status with the help of computer technology continuously available, are mentioned only in passing.

4 Application problem resolution model

You will find an application of the theory of inventory control models to the specific case of the company operating in the automotive industry. Data were obtained during a data collection for the case study in 2017. It was significantly affected by the crisis and the challenge is to figure out how big should be the optimal supply of components, which are optimal inventory costs and what the optimal level of safety stock.

The company is a company producing metal components for the automotive industry.

In terms of the automotive industry it is a medium-sized company of about 200 employees and a monthly turnover of 1,6 million EUR (specific data from January 2017). The company is engaged in several specific projects for different customers, the most important is the production of the rear axle for Opel. The rear axle is produced on automatic robotic line and the main component of which is

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purchased is the torsion bar, supplied by German company Benteler. In the automotive industry is often applied system where the final manufacturer defines to its supplier suppliers of raw materials or components. The final manufacturer is often a stake in the negotiations of suppliers with their suppliers on prices. This also applies in this case.

Company Opel was one of the automakers that have been most affected by the crisis. Demand dropped significantly and Opel closed the plant in Antwerp and Bochum. This situation significantly hit the company, which decreased significantly call offs by about 30%. In the automotive industry, manufacturers often guarantee the final annual volume suppliers with some variation. In this specific case it was 140 000 pieces of rear axles + - 10%. In the case of overflow or underflow volume should automaker under the contract provide compensation. In this particular case, which is solved at the highest level of management companies, unfortunately due to the financial situation of the company Opel and given promises of future projects, Opel did not provide any compensation.

Task is as follows: Figure out how big should be the optimal batch of torsion bars, which are optimal storage costs of this component and what should be the safety stock.

4.1 Evaluation of all models and model selection for calculation

The simplest model for use appears the deterministic model EOQ. But it has several assumptions, which the use of the model in reality considerably limit. Limiting assumptions are the following: the demand is known and constant, stock draw is steady and the size of the supply is constant. So in real cases the use of this model is limited, on the other hand, suppliers in the automotive industry are equipped with sophisticated information systems that are capable of at the lowest cost to order deliveries equally and deliveries are almost constant.

Model Transitional dissatisfaction demand can not be used in our particular case. In the automotive industry is not calculated the dissatisfaction with demand. Already mentioned the huge cost of stopping the assembly line of automobiles exclusive use of this smodel.

POQ production model is divided into the production and consumption cycle and assumptions apply here that the size of the supply is constant and drawing from store is uniform. These assumptions are exceptional in practice and the model works primarily with supplies of finished products and it is not our case.

Model rebates is not not usable in the automotive industry, customer requirements are most often defined as annual volumes with some deviation (usually 10%) and a higher quantity delivered is inadmissible.

The stochastic model created a singl stock, which is described above, it is not for this particular study suitable because a stock is created once in this model. This stock is suitable for seasonal goods, automotive supplies constitute repeatedly according to current customer requirements with the aim for the lowest possible inventory.

Stochastic model transitional dissatisfaction demand is not suitable precisely because of unsatisfied demand.

Stochastic two-period models with no setup cost and stochastic multiperiod models with no setup cost are too complicated and because of the immediate knowledge of the stock due to information systém best suited for continuous model. For calculating optimum supply costs and insurance stocks will therefore be elected one of stochastic models, *stochastic model of continuous demand*. The auxiliary storage unit calculations and cost will be made using a derivation of deterministic EOQ model.

4.2 Calculation of optimal inventory and safety stock

Specific manual input data model are as follows :

The average annual demand for the rear axle Opel Zafira	μ_Q = 140 000 pcs
Standart deviation (+-10%)	σ_Q = 14 000 pcs
Acquisition time of delivery (delivery 2 x per month)	d = 1/24 year
Purchase price of torsion bar (one torsion bar in one axle)	18 EUR

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There are deduced even more items:
The Annual storage cost c_1 per one torsion bar:
When packing 50 pieces per pallet, pallet sizes 2 m2, storage costs 0,11 EUR / day / m2, the costs for loading pallets 14,3 EUR / palette and unloading costs 10,7 EUR / pallet is
c_1 = 0,11*365*2/50 + 14,3/50 + 10,7/50 = 2,07 EUR.
Fixed cost c_2 connected with each delivery:
There are included all administrative costs in this item connected with the order of delivery and a trasport of goods. Transport costs are fixed with transport provider by an agreement for one year, they are 643 EUR, the other administrative costs connected with the delivery are 143 EUR.
In total thus c_2 = 786 EUR.
Demand during the acquisition lead times *d* is μ_d = 140 000/24 = 5833 pcs
And standart deviation of this demand is σ_d = 14 000/24 = 583 pcs
Optimum supply amount q^* is following:

$$q^* = \sqrt{\frac{2Qc_2}{c_1}} = \sqrt{\frac{2 \cdot 140000 \cdot 786}{2,07}} = 10311 \text{ pcs}$$

point of next order r^* is :

$$r^* = \mu_Q d = 140\,000\ (1/24) = 5833 \text{ pcs}$$

Now even calculate the optimal total cost by EOQ model :

$$N^* = \sqrt{2Qc_1c_2} = \sqrt{2 \cdot 140000 \cdot 2,07 \cdot 786} = 21344 \text{ EUR}$$

As mentioned above, we assumed that the demand for the cost of delivery period *d* has a normal distribution $N(\mu_d, \sigma_d) = N(5833,583)$

From tables with distribution function of the standard normal distribution *N (0,1)* which were to be transformed random variable *Qd (Formula 2)* determine what value z_γ matches to the operating level γ. Given that suppliers in the automotive industry are committed to the creation of safety stocks, taking into account only the operating level of 0.99 and higher.
Thus from table for $z_{0,99}$ = 2,327.
Safety stock will be $w \geq z_{0,99}\sigma_d$ = 2,327 . 583 = 1357 pcs
The order should therefore be exposed when the inventory level drops to

$$r^* + w = 5833 + 1357 = 7190 \text{ pcs}$$

Will also increase the mean cost from deterministic EOQ costs

to $\mu_N = \sqrt{2\mu_Q c_1 c_2} + c_1 w$ = 21 344 + 1357. 2,07 = 24 153 EUR.

Thus let us summarize the results: level of optimal supply torsion bar is q^* = 10 311 pcs, point of another order r^* = 5833 pcs, safety stock w = 1357 pieces and the mean total cost at the operating level of 99% is 24 153 EUR.

In practice when determining the amount of deliveries, are more reflected transport costs and the quantities to be ordered as multiple transport units (eg. Containers) or in case of larger volumes full trucks. The safety stock is in practice often a multiple of the daily manufacturing process needs.

In our particular case five-day cycle (50 weeks a year, calculates the shutdown of two weeks in the summer one week in winter, thus 140 000/250 = *560 pcs a day*, which is real daily need. The calculated value of safety stock w = 1357 pcs is very close to a two-day needs of 560 · 2 = 1320 pieces used in practice. The calculated results which have been achieved by using the stochastic model of continuous demand are very close to the real values, which are normally operated and defined by information systems (MRP). The chosen model therefore well describes the work of the stocks in a company operating in the automotive industry. Due to the uncertainty of orders from customers in the

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automotive industry it is definitely preferable to use a stochastic model that works with an unlimited demand. On the one hand due to uncertain demand are total costs and a safety stock higher, on the other hand in crisis there is a fear of a drop in orders and the associated effort to minimize inventory costs. In this case the company's management faces a decision whether not to reduce the service level of 99% to a lower value and thus reduce safety stock.

5 Case study Activities for purchase logistics in crisis

5.1 Goal of research

The subject of the research is to find out the consequences of the economic crisis on the purchase of companies in the automotive industry, its state and preparedness in crisis, the crisis impact on firms, the concrete solution of the crisis situation in 2008 and the readiness for the next crisis. The aim of the study is to gather the possible impacts of the economic crisis on the logistics of purchasing automotive manufacturing companies and defining recommendations on what to prepare for the crisis and what measures to take for more resilience.

5.2 Metodology of research

In order to obtain the data and information qualitative the research was applied in the form of a case study. As Hendl (2016) states, research through a case study focuses on a detailed description and analysis of one or a few cases. The case study is about capturing the complexity of the case and describing relationships in their complexity. The advantage is the depth capture of the description and the acquisition of the overall context. A disadvantage is that the results of a case study may represent a cluster of subjective impressions and, unlike qualitative research, its unstructured character is difficult to interpret. However, these problems can be avoided by using appropriate procedures to ensure the validity of the results. It is assumed that a thorough analysis of one case can be better understood in other similar cases. The examined case is included in the wider context at the end of the study, it can be compared with other cases and the validity of the results is also evaluated. When multiple cases are considered, we are talking about multiple case studies. In the case study, the most frequently asked questions are why and how, in statistical research, questions such as who, what, where, and how many, are. In a statistical survey, cases are selected randomly, in a case study. In terms of data, the case study is flexible, interviews or observations are used. The case study is characterized by the fact that it differs from laboratory, isolated research by the fact that research using case studies takes place mainly in the field. Realization of the case study takes place in several steps that are interrelated:

- Determination of research questions,
- Case selection, data analysis, determination of collection methods,
- Preparation of data collection - organization of data in the database, preparation of the data collection procedure,
- Data collection itself is done systematically using multiple sources, recording and documentation,
- Analysis and interpretation of data, case analysis, data comparison between cases,
- Output preparation - description of the case in its complexity.

5.3 Case study

5.3.1 Case study assumptions

According to the methodology, a collective case study will be used, based on the assumption that by following multiple cases, a deeper insight into the issue can be achieved. In the case study, companies operating in the automotive industry were selected and their research concerned their experience with the impact of the economic crisis on purchasing logistics. The study also included data collection to compute and compare a suitable stock model. The gathering of information took the form of

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partially structured managed interviews.The initial effort was to reach medium-sized companies supplying automotive components, however, the logistics purchase representatives most of the respondents were either very busy or allegedly unable to communicate specific information from the corporate environment, so companies involved in the automotive industry of all sizes were included in the research. Out of 32 addressed companies, their logistics and purchasing representatives agreed to a controlled interview in 18 cases. As a major problem, the fluctuation of workers in positions in logistics and purchasing proved to be a major problem, with only 7 companies out of the 18 listed in the logistics of purchasing people who had personal experience with the impact of the economic crisis in 2008 on purchasing and logistics in companies automotive industry.The protocol for the case study was first prepared. The protocol contained the identification of the respondents, the purpose and purpose of the research, questions and sub-questions with the predominance of open open questions supplemented by selective questions (yes / no). The following questions were defined for research:

- The impact of the economic crisis on the company.
- Impact of the crisis on purchasing logistics.
- Measures taken.
- Work with warehouse supplies.
- The impact of the crisis on organizational structures.
- Impact of the crisis on supplier contracts, work with suppliers
- Impact on logistics purchasing organization
- Existence of risk analysis and company readiness for further potential crisis.

Each circuit contained additional subpoints and was processed separately. During the research and data collection, additional findings have been added, which have been extended by the protocol itself. Respondents not only outlined the measures to prevent the impact of the crisis but also assessed the individual measures, presented the advantages and disadvantages, the effectiveness of the measures,or the possibility of generalization.The survey was conducted only during a personal interview following a prior telephone appointment. The research was attended either by a logistics manager or a purchasing manager, or both.

5.3.2 Research and data collection

Research and data collection was conducted at companies supplying automotive components in the Moravian-Silesian region, Zlín region, Olomouc region and Usti region. Of the 32 addressed companies, 18 companies were willing to participate in the research, but only 7 companies had their representatives experienced with the impact of the crisis. Data collection took place in the first half of 2017.

5.3.3 Lessons learned from analysis of the individual case studies

For all 7 companies that were willing to share information, the following were found: All companies were involved in supply chains, and all the consequences of the economic crisis during the fall of 2008 were very unexpected.

Economic crisis impacts on companies.

The main and immediate impact mentioned by representatives of all companies was the decline in orders. The automotive industry often uses the term "call-offs", and these call-offss almost unexpectedly dropped. All respondents, in accordance with custom in the automotive industry, receive from customers every year estimates of their needs for 2 to 3 years with the specification of the next year. For all, the orders dropped unexpectedly when updating the information. The first drop in the revocted volume occurred in September and October 2008, as information on the decline in car production spread through the logistics chain from a first line supplier to a raw material supplier. Further drops in the orders

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came until May 2009, when the decline stopped. One respondent mentioned stop of the declineof orders until February 2010.

Impact of the crisis on purchasing logistics

The decline in orders that significantly affected companies in the 2008 economic crisis also had a major impact on purchasing logistics and logistics as a whole. In first moment finished goods began to accumulate in warehouses. Purchase logistics had the greatest impact on the subsequent accumulated inventory of input materials and components. One respondent said: *After dropping orders I suddenly instead of the weekly stock allowance had stock for a whole month.* Due to declining customer appeals it was necessary to reduce requirements towards suppliers. As all seven respondents said, the impact of the crisis on purchasing logistics consisted primarily of the need for intensive control (reduction) of stock of input materials and components, intensive work and communication with suppliers, and review of contracts.

Measures taken

All survey respondents said the biggest need for purchasing logistics in the crisis was to reduce inventory. This was followed by further steps, especially work with suppliers. Purchasing logistics workers have thus had to start to communicate more intensely with vendors. Four respondents said that their suppliers had initially refused to reduce inputs, but later did so. As a further measure, changes were made to the shift in the input warehouses, change of supplier and reduction of warehouse staff.

Inventory management

Work with stocks appeared to be the most important, according to respondents. Due to declining customer requirements inventory of input materials and components had to be reduced as well. One Respondent said: *While the last ten years our customers wanted more and we had to add the production capacity to have enough components in stock, suddenly the management wanted to reduce the stock also below the safety level*. Two representatives said that they had failed to reduce requirements to suppliers in time and the stock increased considerably.

The impact of the crisis on organizational structures

Five respondents out of seven reported that the crisis had an impact on the organizational structure of their company's logistics purchasing, although in three cases it was a temporary change. Twice was the merger of purchasing and logistics, once the purchasing logistics was temporarily included in the production department, once the purchase was temporarily included in the financial department and once the purchase was temporarily subordinated directly to the CEO, who operatively managed the impact of the crisis as a crisis manager and participated in negotiations with key suppliers. This company was hit very strongly by the crisis and later a project team was created of the top representatives of logistics, purchasing, finance and in the presence of the CEO. This team then decided which suppliers the company pays in time and who will be consciously delayed in payments.

Impact of the crisis on contracts with suppliers and work with them

After the impact of the crisis the buyers experienced a really demanding period. Immediately there was a need to reduce stock and start negotiating with suppliers to lower requirements or reduce the price. Probably the toughest moments were experienced by two companies, which declined considerably as suppliers to the automotive industry, but their suppliers were large multinationals with a strong negotiating position. These companies, which supplied steel coils and plastic granules, did not only operate in the automotive industry but also supplied their products to other sectors where the drop in requirements was not so great and their representatives refused to accede to a significant and

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unexpected drop in requirements. Both companies have, in part, taken away some of their original requiremets from some suppliers, so the consequences of the crisis have been left on their shoulders. Respondents from four companies said they were delaying payments to suppliers. Two respondents due to the worsened economic situation forced suppliers to lower the price ofcomponents, three respondents were forced to change suppliers. Two respondents said their suppliers were asking for a price increase because they could only guarantee the original price for the original higher volumes. Five purchasing respondents said they would look for alternative suppliers after difficult negotiations with suppliers to replace existing suppliers in the event of problems. Everyone agreed that it was very important how contracts with suppliers were built, what room for maneuver they had opened up. In the end, it was often said that the bargaining happened according to the bargaining power.

Influence on logistics purchasing organization

Here, six respondents out of seven mentioned that they did not avoid reducing the purchasing logistics workers, in five cases there was a reduction in the number of warehouse workers. In one case, this was the link with the financial department and increased support for negotiation with suppliers. In two cases, the introduction of "unloading windows" in the warehouse of purchasing logistics was mentioned. Respondents said that the crisis began to experience more delays, incomplete deliveries and all this resulted in a critical situation in the warehouse. The trucks were stacked in the warehouse, the warehouse keepers were not trying to unload and load and they made mistakes under pressure. Unloading windows or fixed landing dates for individual vendors helped to better organize work in the warehouse.

Risk analysis and company readiness for further potential crisis.

According to the research it was found that in two companies from seven at the time of the crisis in 2008 a risk analysis was carried out. Both respondents consistently stated that the general risk analysis was processed in the company, but the reaction on sudden decline in orders and subsequent measures were not mentioned in this risk analysis. 5 respondents said they currently have a risk analysis in their company, in one case they call it an emergency plan. Out of these five, only one company representative stated that more specific risks and follow-up measures were presented in the analysis. All respondents agreed that the economic crisis of 2008 and the significant drop in requrements would no longer be felt in the working environment. Five of them mentioned at least the basic general readiness of the company for further potential crisis, but specific plans and instructions for purchasing logistics are not prepared in any company. One respondent literally said:*I remember the crisis, it was very demanding, but it's been a long time. I have some knowledge, but there is no time to process anything. Today we are in a state where we are almost not running the customer orders and we are not dealing with other things.* Another respondent characterized the situation in the company*: I am the second oldest one in the company and the crisis I experienced here. Since then, we will never exceed monthly stocks in the warehouse. In companies which I cooperate with people in purchase logistics do not work longer than six years. When the next economic crisis comes, they will be surprised.* Respondents have also mentioned a certain limitation of possible responses to external influences as businesses often form part of the logistics chain and must adapt within this chain. On the basis of the findings it can be said that there are certain procedures and processes in place for the companies to mitigate the risks of the economic crisis, but they are represented to a varying extent and are not comprehensively processed.

Summary

Main task for a purchase from headquarters in time of an economic crisis is cooperation on reducing inventory, to inform suppliers about requirements reduction and negotiating price reductions. The concept of corporate involvement in logistics chains often mentiones a long-term ineffectiveness of

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one-side pressure on prices of inputs and vice versa the need for cooperation and coordination drop-offs throughout the whole supply chain. If the company is deeply affected by the crisis and it has cash flow problems, it delays in payments. At that time a purchase has to solve all communication and negotiating with suppliers about payments rests and it closely cooperates with financial deparment. There are situations that delay payments are paid only to selected suppliers.

As already mentioned, the core activity of purchase in a crisis is to project a decline in customer requirements to a decreasing of supplier´s call offs . If the supply chain is building in the long term and is built on trust, the supplier usually accepts this fall. It can happen that in case of drop-offs the supplier instead of a price decreasing pushes for price increase because the current price of goods is able to guarantee only when volumes are unreduced. It is important how a contract management works in the company, how they are built contracts with suppliers in this moment.

5.4 Necessary steps in the purchase logistics in times of economic crisis

Errors that may occur during the economic crisis are particularly in the slow or delayed reaction to the effects of the economic crisis, in managerial errors, in subjective belief that the company is prepared for the crisis and in the absence of risk analysis. (Kbt 2012)

Logistics manager or purchase manager implements in the production company below mentioned steps and all those steps are in synergy with the activity of top management and other departments, especially financial and production department.

1. Decrease in inventory – when the first signs of crisis appear, it is necessary to focus on inventory and reduce it to the maximum. This concerns not only inputs of materials and components, but also a work in progress and finished goods. This decrease is needed to implement based on information from outer space and estimates of market developments. It assumes a general overview for managers, the ability to see things in context and the art to take the risk by reducing safety stocks, as mentioned in chapter 5 for the calculation of safety stock.

2. Projecting drop-offs orders to suppliers – immediately after the drop in customer requirements due to the economic crisis to reflect reduced requirements to suppliers offs. Practical experience definitly confirms that in case of delay of the delegation decreased requirements on suppliers leads to a significant increase in unwanted inventories that cause huge problems in the economic crisis.

3. Negotiating with suppliers to reduce prices - to take this step a company decides when it is hit by crisis very hard. It is extremely unpopular for the suppliers and in the case of danger to the very existence of the company it is one of the key action. The supplier is often faced with the choice to reduce prices of goods supplied or lose the customer.

4. Delayed payments to suppliers - This is a questionable activity from the ethical point of view, in practice it is often used however. In order to improve current financial situation the company deliberately delays some payments. The list of those whose payments are delayed is carefully assessed and selected.

5. The existence of a list of alternative suppliers - To have prepared such a list is helpful in general. Some end manufacturers in the automotive industry require to have processed this list, it can be used in any trouble with existing suppliers. For exemple the supplier is not willing at any cost to reduce the contracted supply or is itself hit by the crisis and it is unable to fulfill offs. Than a purchase bargains on supplies with alternative suppliers.

6 Conclusion

Within this work are described the purchase logistics, activities in purchase logistics, purchasing and logistics position in the organizational structures. Furthermore the work described types of inventory, inventory models and the impact of the economic crisis on purchasing logistics. For a specific

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calculation of the optimal delivery, safety stock and average value of storage and cost companies operating in the automotive industry were selected and used as a stochastic model of continuous demand. Since the calculated values are close to the values used in reality, the selected model well quantifies the issue. Than the paper contains a case study of crisis impacts on purchase logistics suppliers in automotive industry. Based on the case study are defined mesures that are needed within the logistics department of the production company in order to best absorb the impact of any economic crisis.

This issue is rarely mentioned in professional studies that discuss the topic, and for this reason the work can bring some new knowledge from practice. Personal observation is that many companies because of the crisis reduced the organizational structure and due to the drop in orders decreased numbers of workers. When restarting a gradual increase in orders, the company tried to face increased orders by existing number of employees. Though companies because of the crisis temporarily decreased revenues, many of them achieved this by the reduction of organizational structures and staffing higher labor productivity, which would have been very difficult under normal conditions. From this perspective the impact of the economic crisis had a positive effect.

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