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The problem of assessing risk in the supply chain of a logistics process

Keywords

risk, supply chain, logistics process

Abstract

Process of suppliers selection, as well as cooperation between suppliers and manufacturers, are a significant problem for today's companies. Producers negotiate and arrange with their subcontractors to ensure a continuity of production. Following this, one of the major problem is supplier evaluation and supply risk assessment in order to avoid delays, which may seriously affect the producers' ability.

In the paper there are presented the main types of risk and the methods of its classification and evaluation used in logistic processes performance. The analysed problem is to be discussed on the example of Whirlpool-Polar company from Poland. For the presented company, there is investigated supplier evaluation process, suppliers classification with the relation of their purchasing and bargaining power to the degree of their obligations fulfilment. Moreover, there is defined the supply risk concept, what gives the possibility to compare the suppliers purchasing power with the defined supply risk. Later, there are presented main possibilities to reduce the supply risk by using a "milk run" method with a number of variants of the simulation and its evaluations.

The presented results comply with the profitability of transport in the case of round-trip transportation performance. Transport of goods is cost effective when the usage of the truck transport capacity will be at least 85%. Following this, the presented research analysis result gives the possibility to reduce risk in terms of reducing disruptions occurrence consequences, when the probabilities of their appearance remain at the same level.

1. Definition of risk in a logistics process

Risk in the scientific literature is defined on the basis of various disciplines of knowledge and theories such as economy, legal sciences, psychology, statistics and probability theory. The very etymology of the term "risk" has not yet been indisputably clarified. It may be noted that the key aspect of the word "risk" is danger. According to one definition risk is a combination of factors, activities or actions that cause harm to the body, material loss or other damage. [1] In the area of economy an important aspect of risk is action aimed to achieve a particular objective. In the course of pursuing this objective the possibility of not achieving the objective has to be taken into account, and so by a different definition risk is the cumulative effect of the probability of uncertain events that may positively or negatively affect the implementation of the project [5].

To effectively reduce risk one should perform an analysis whose basic steps are [7]:

- identification
- measurement
- navigation
- monitoring and control.

Identification:
It consists in finding entities which have been affected by risk as well as determining causes and possible consequences of risk. It is necessary to observe risk occurring in different parts of a company, as well as to understand it. The result of risk identification should be a well-documented description of the various types of risk in the company.

Measurement:
This step involves assigning numerical values to the risk of an entire project as well as for the risk occurring in individual parts of the system. It allows us to determine the chance of achieving our objectives and indicates the locations of the greatest hazards. Through this process we can determine the

overall consequences associated with the implementation of the project.

Navigation:
It consists in determining risk response options that will reduce the probability of risk occurrence and risk impact when a hazard becomes reality.

Monitoring and control:
It consists in supervising risk occurrence areas, execution of corrective actions in a situation of risk occurrence, reporting and evaluation of implemented activities.
All stages of risk management process are shown in *Figure 1*.
The risk in the supply chain can therefore be understood as the effects of the adoption of an inappropriate strategy, erroneous decisions, non-optimal configuration of the logistics system, resulting, for example, from the number of links in the supply chain, accessibility to major transportation hubs or the number and types of distribution channels [6]. Risk exposure of the supply chain can be defined as its sensitivity to hazards occurring within organizations creating it, as well as between these organizations. Thus, the sources affecting risk in the supply chain are as follows [7]:

– processes occurring in the supply chain,
– suppliers - breach of contract, unsatisfactory quality of components, lack of timely deliveries
– customers - change of requirements regarding the level of service,
– services provider - for example mistakes of consulting firms, unfavorable contracts with logistic operators, low level of service,
– competitors (industry and peer group).

All in all, the process of supply chain risk management can be defined as: identification and navigation of risk in the links making up the supply chain and internal processes implemented in the supply chain and related to the flow of goods, services and information through integrated activities of enterprises making up the chain of supply.

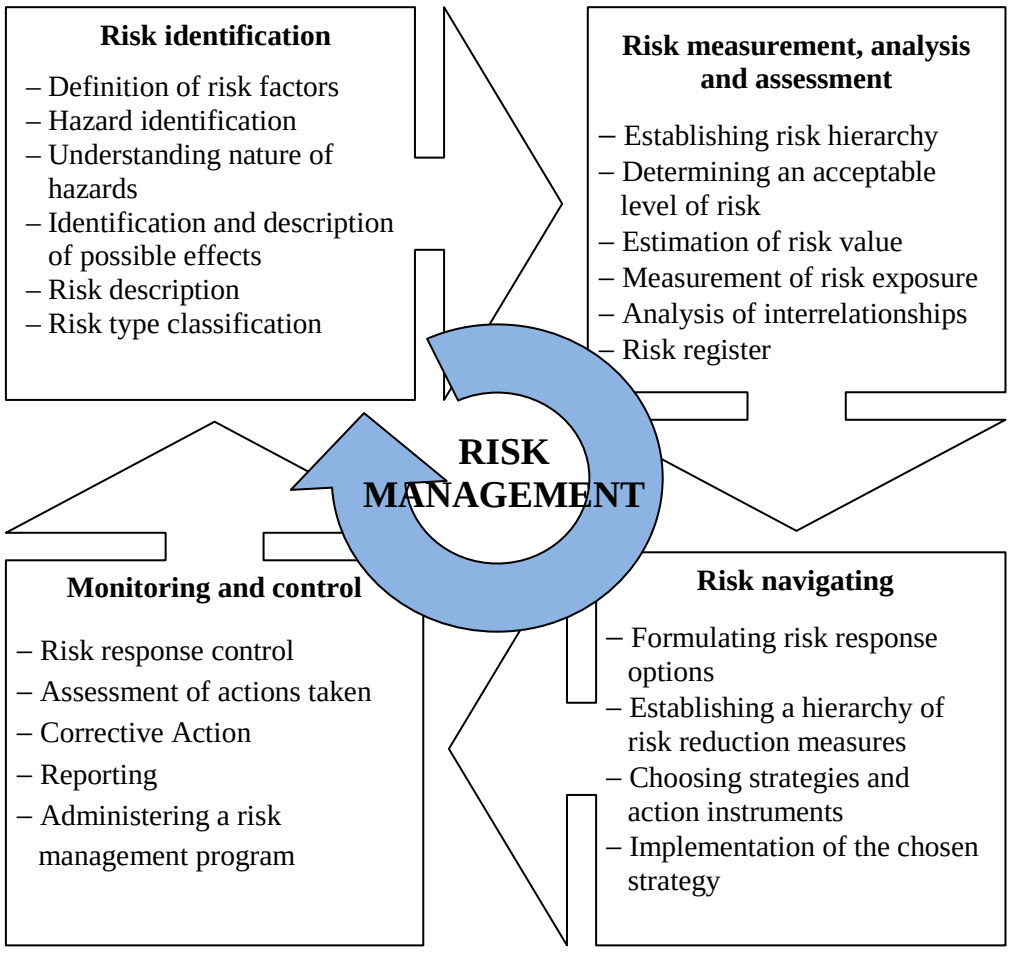

Figure 1. Stages of risk management process [3]

The main processes carried out within the supply chain include [6]:

- customer relationship management
- customer service management
- demand management
- order execution
- production flow management
- supply
- product development and commercialization.

Each of these processes involves other types of risks. When identifying risks, it is important to take into account the risks directly associated with individual companies forming part of the supply chain, as well as the risk occurring in the processes jointly implemented by the said companies. Disruptions which occur in one chain link may result in adverse events in the subsequent links.
Risk management in the supply chain should be started from drawing maps of the processes taking place in companies of suppliers, producers and recipients and determining the relationships between these processes. Detailed analysis of activities carried out as part of a particular process allows us to precisely assign it to adequate risk groups.

2. Description of the analyzed supply chain

The supply chain in the enterprise has a very simple and uncomplicated design. Whirlpool - Polar is its last link before the distributors of household appliances and end customers. The chain links preceding Whirlpool are direct suppliers and their suppliers.
The headquarters of Whirlpool for Europe, in Comerio, Italy is the place where all orders for dishwashers from the company branch offices in different countries are collected and then grouped and allocated for production in individual factories. In Europe, in addition to WHIRLPOOL representatives, orders may also be placed by supermarkets and large chain stores. The production plan for each month is always imported into the system in the third week of the month while production schedules updates are carried out once a week, usually on Monday. The total number of dishwashers which is intended for each country is only an estimated quantity calculated on the basis of a forecast.
In relations with suppliers Whirlpool relies on forecasts which specify the assumed volume of production, and hence the demand concerning a predetermined period. The suppliers are presented forecasts for a period of one month or quarter. They are also provided with forecasts in the case of any changes in production volume, such as launch of additional shift. After analyzing the forecasted demand the supplier decides whether it will be able to satisfy orders.

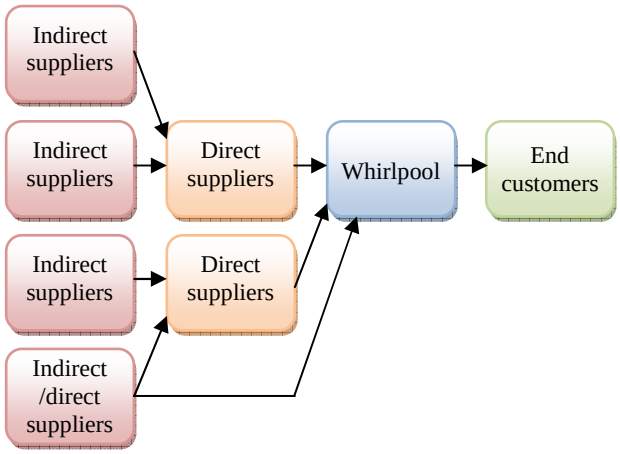

Figure 2. General scheme of the supply chain at the Whirlpool company in Wrocław

2.1. Identification of mistakes

The enterprise maintains the inventory value at the level of about 10 million PLN, which is equivalent to maintaining the inventory lasting for 10 days. In practice, however, the inventory lasts for up to 2 days. This is because some components are more expensive than others and are not needed for on-going production, that is, they are used only in some models, while others, such as small and inexpensive items, not used in high quantities to produce one dishwasher, run out quickly, and, in addition, they are needed for each product.
An important factor in shaping and scheduling deliveries to the factories are consolidation centers, which are located in Cassina, Italy, and Ottmarsheim, north of Stuttgart, Germany.
The first of them is located almost in the immediate vicinity of the Whirlpool European Headquarters. Italian, and in particular local suppliers deliver components for Polar to this location. When parts gathered in the center reach an amount sufficient to send one full car, they are loaded and transported to Wrocław.
In the supply chain there are various problems ranging from suppliers and ending with the receipt of the final product by the customer.
The most troublesome and the most common difficulties occur during collaboration with the company's trusted and proven suppliers.
Discrepancies very often occur when checking orders, which is due to the frequent sending of a different number of goods than the number presented in the order. Such cases may include the following activities on the part of providers:

- loading a truck with a bigger number of components,
- and the exactly opposite situation when the number of goods on a truck is insufficient.

Information on the excess or lack of goods reaches the supply experts at the time of unloading. Sometimes it happens that such information reaches the logistics department during the customs clearance procedure of transport from outside the borders of the union.

As for the first situation, it causes a systematic increase in inventory volume, and thus increases in the value of the components in stock and reduction of storage space, which is already quite small.

In the latter case, the situation is much more serious because when the provided element is in deficit and necessary to the on-going production its absence will stop the assembly line, and thus cause serious losses and delays.

It often happens that there are minor problems with the punctuality of delivery or that it comes just in time, and the more necessary parts are used for production already on the day of delivery, which results in a significant stock rotation.

Out of all of its suppliers, more than half of them carry out production almost exclusively for Whirlpool corporation. This is because this producer of household appliances has several factories in Europe and willingly takes materials from its regular and reliable manufacturers who meet all quality requirements.

On the basis of the information obtained from the enterprise suppliers can be divided into three groups:

- credible suppliers
- medium suppliers
- problem suppliers

The first group consists of good suppliers *(top suppliers)*, who should be role models for others. With these providers there are virtually no problems, and in the case of any misunderstandings and inconsistencies they show willingness to cooperate.

The second group comprises of medium suppliers. They are not leaders in their field but they do not impede cooperation.

The third group consists of problem suppliers. Working with them is quite difficult for each producer and special attention has to be paid to them.

2.2. Criteria for assessing providers

During the assessment of suppliers the following criteria have been taken into account:

- whether the delivery was on time,
- whether the delivery consisted of the ordered amount of goods,
- whether the parts provided by the supplier meet the quality requirements of the recipient,
- what is the bargaining power of the supplier,
- what is the supply risk - whether the supplier carries out orders, or whether the supplier often does not fulfill the entrusted orders and the company has to use other sources in order to maintain continuity of production.

Table 1 presents the criteria for assessing a supplier. The better is the cooperation with a particular supplier the more points the supplier receives for a given criterion.

The criteria have been established after a discussion with managers. These are the factors that the Whirlpool-Polar company holds crucial when dealing with suppliers.

Table 1. Criteria for assessing suppliers (example)

Supplier	Criteria	Rating						Granted points
		3 points		2 points		1 point		
Supplier X	Delivery on time	On time		One day of delay	X	Over one day of delay		2
	Meeting quantitative requirements	Precision	X	Deviation (+)		Deviation (+ or –)		3
	Bargaining power	Weak		Medium	X	Strong		2
	Quality of parts	95-100%	X	85-94%		<=84%		3
	Supply risk	Low		Medium	X	High		2
						TOTAL		**12**

Legend:
15-14 Top supplier
13-12 Medium supplier
11-5 Problem supplier

All the criteria taken into account are an average, rather than individual result.
As for the first criterion, i.e. delivery on time, we have focused primarily on whether the supplier systematically and accurately delivers the goods to the factory. Individual delays caused by exceptional events are not taken into account.
The second criterion, namely meeting quantitative requirements, is one of the most important because what is important here is whether the components come in such quantities as they should or whether the supplier is rather trying to move its "warehouse" to the premises of the factory.
The third indicator - the bargaining power - takes into account whether the cooperating company takes advantage of the fact that it is larger or that it is the only supplier. It is obvious that if the company is the only supplier, it can force even a greater production company to pay a higher price for its goods, but only until the production company finds a new partner.
The fourth criterion, the quality of parts, is crucial, because bad quality items are rejected, which causes shortages and the need to file complaints.
When it comes to the last criterion, that is supply risk, the number of allocated points was affected by the fact that most of the suppliers are from outside Poland and Whirlpool is not the only recipient of the components produced by them. There were situations when the supply was not implemented due to lack of sufficient production capacity of the supplier, in which case the goods prepared for Whirlpool were shipped to a more important recipient while the order of Wrocław factory was delayed or not implemented at all. In such situations the company had to use other sources (supporting suppliers) in order to maintain continuity of production. Supply risk in this case can be defined as the probability that the supply will not be carried out in the time which allows the use of components for production in accordance with established rules.

3. Analysis and risk assessment

The analysis covered all Whirlpool's (i.e., dishwasher production plant's) providers, making it possible to achieve a holistic view on the process of stocking up the factory.
After having analyzed every supplier, we have obtained the following a cross-section of providers:

- 18 - credible supplier (top supplier) - no any problems with these suppliers. Orders are always delivered on time and on order quantities)
- 27 average vendor (supplier medium) - van who meet the obligations, but there are the trips and delays
- 34 suppliers problem (the problem of supplier) - suppliers with whom the company has the most problems, due to the described in the previous section deliveries criteria.

45% of all suppliers are problem suppliers. The fact that the main contractors of the enterprise, such as: Bauknecht, Tectro, Flextronics, AWECO, Eifler and many others are also in this group, and that they are the main and only companies providing us with specific components leads to frequent situations in which continuity of production is at stake, if not even stopped.
The ABC analysis of suppliers shows that "A" suppliers, that is the biggest suppliers in terms of the value of the delivered components, provide up to 80% of the value of all the materials. This group includes only 13 out of 79 suppliers. So it can be noted how big the risk is when most of them are in the third group of suppliers, namely the problem suppliers group.
Groups "B" and "C" include suppliers from which small quantities or relatively inexpensive items are taken. These are the supporting providers but they also play a very important role because without them there would be no production, and certainly the products manufactured by Whirlpool-Polar would not be of such a good quality.
Figure 4 shows the six major suppliers who provide up to 50% of all the components necessary for the production. The values have been estimated in terms of the components necessary to produce one complete and ready to use dishwasher.
The supplier selected in *Figure 4* provide the goods of considerable value in terms of one dishwasher. They may be single but expensive items, or a large number of small parts of insignificant value.
Figure 5 presents the relationship between the value of purchased components and the degree of obligations fulfillment by counterparties. Only providers from "A" or "B" group have been taken into account because they constitute 95% of all suppliers. As can be seen only a few of them do not create problems while the major ones seldom fulfill their obligations completely. There are very frequent situations where they do not deliver what they should or generate discrepancies and errors in what was ordered and what was actually loaded and sent to the Wrocław factory.
Typical supply errors include:

- incorrect number of parts in a supply – a too high number, which generates additional inventory, or a too small number, which causes stock deficiencies,
- unacceptable quality of supplied parts - it causes gaps in inventory and poses a threat to the continuity of production. Such delivery may be

rejected in its entirety or we can incur additional costs to segregate acceptable parts so as not to break the continuity of production,

– supply of ordered parts delivered too early, for example, for a week or more in advance. Those causes an excess of components in the warehouse and creates problems with placing items in the specially designated places in the warehouse. There is often a need to store supplies outside the warehouse area.

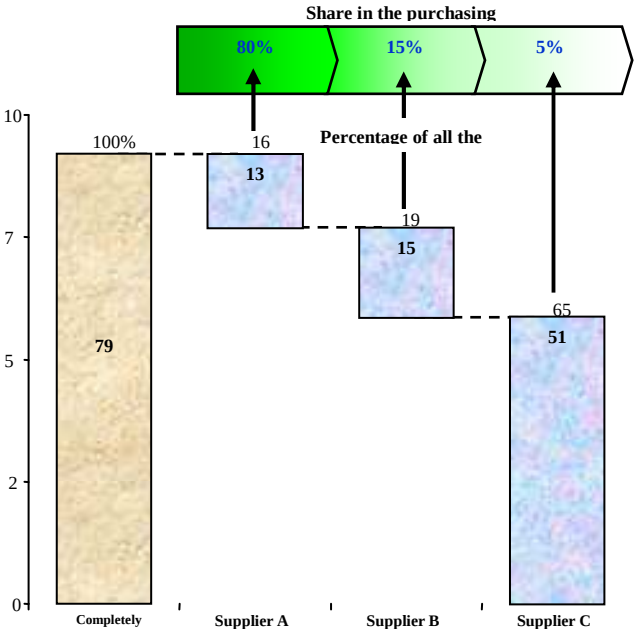

Figure 3. Division of suppliers and their share in the purchasing volume

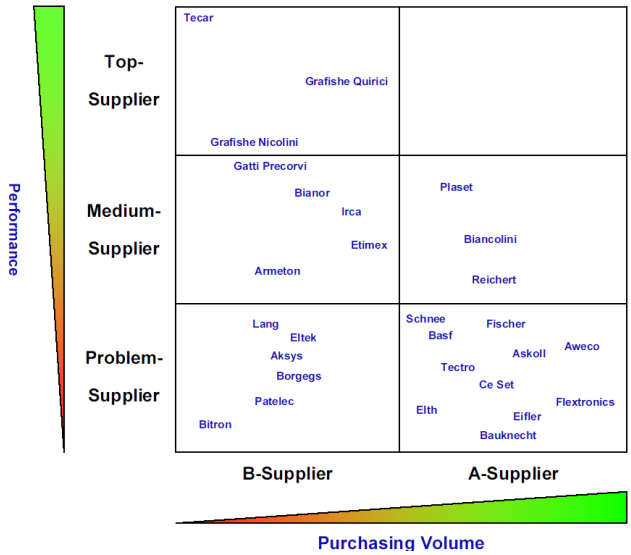

Figure 5. Relationship between the purchasing volume and the degree of obligations fulfillment

Figure 6 shows the relationship between the bargaining power of suppliers and their discharge of contracts and agreements. Stronger and larger producers have greater impact on the agreements made and they often use their "superiority". They can thus impose higher prices and raise the minimum order quantity. Such a situation significantly impedes cooperation but in some cases it is necessary due to the lack of other sources of components. So, the biggest problems arise when dealing with suppliers such as Bauknecht and Tectro, who provide the greatest volume of elements while, on the other hand, Flextronics and CE Set provide the most expensive components.

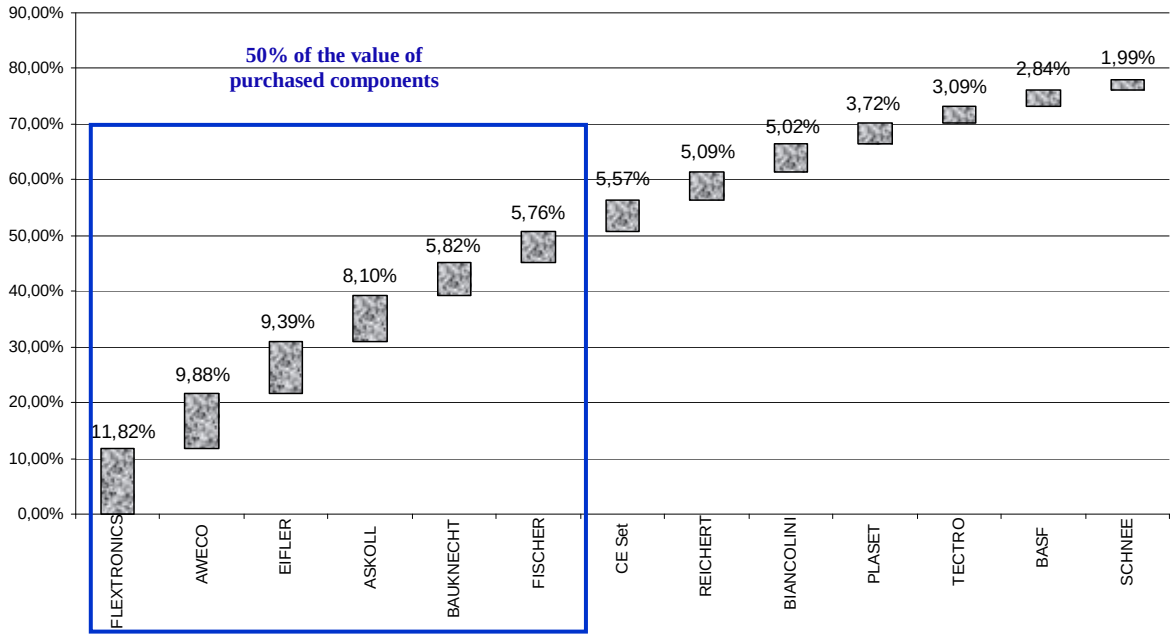

Figure 4. The value of components purchased from "A" suppliers shown in percentages

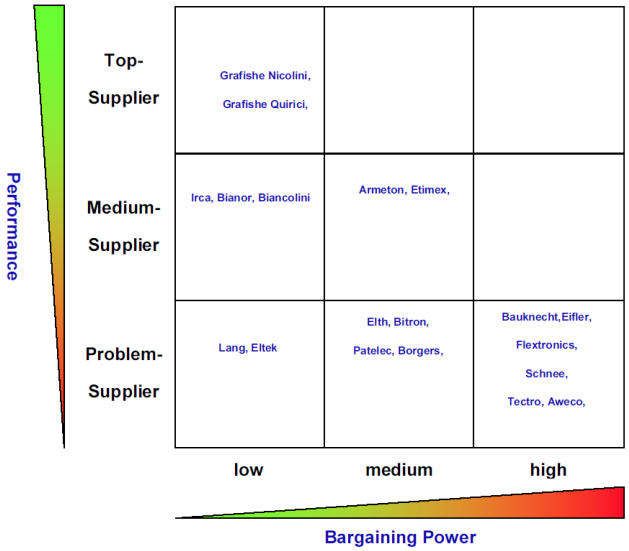

Figure 6. Relationship between the bargaining power and the degree of obligations fulfillment

Small suppliers must yield to Polar, which is greater than they are. Also, they are required to deliver everything on time and in the right amount and the parts supplied by them should be of the highest quality because otherwise they will lose the recipient for their products.

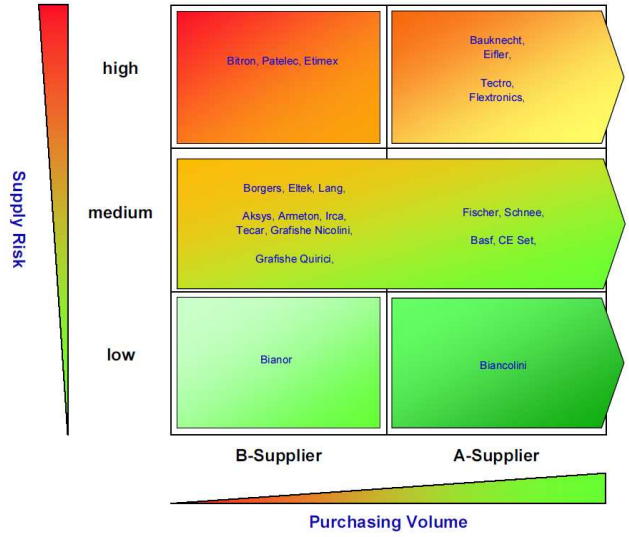

Figure 7. Relationship between the purchasing volume and supply risk

Supply risk is a very important aspect when planning deliveries. *Figure 7* presents the relationship between supply risk and the value of the components purchased by Whirlpool-Polar from its suppliers. Most of the companies cooperating with the Wrocław manufacturer are located in the zone of moderate risk. Major suppliers are in the range of high risk, and the fact that they provide a large amount of components and that the supplies do not always agree with the orders makes cooperation with these companies very difficult at times.
It is these important suppliers that often take advantage of their size and Polar's sensitivity to their bargaining position, which sometimes at a stalemate can lead to serious problems with maintaining continuity of production due to shortages of certain components.

4. The concept of risk reduction

To reduce supply risk and improve inventory management, Whirlpool has introduced a delivery system called "round trip" in which the merchandise is received from multiple suppliers in a smaller amount and by a single means of transport. This solution leads to the increase in the diversity of production components in a delivery process, more frequent deliveries and the resulting reduction of stock fluctuations. In addition, it allows the introduction of the "just in time" principles.
The components taken into account were *common components*, that is, the elements that are used to produce each dishwasher without exception.
After analyzing the number of components necessary for the production and the maximum space and weight capacities of the means of transport, the results shown in *Tables 2-6* have been achieved. All results are averaged and provided in terms of the capacities of the means of transport.
To ensure that the "round trip" transport is applicable and profitable, at least 85% of the truck capacity should be used.

Table 2. Number of shipments and their load for a one-day production

Daily production	1800
Number of working days in a week	1
Production	1800
Percentage fill of a truck	72,22%
Maximum truck tonnage	24000
Gravimetric filling of a truck	75,25%
Necessary number of trucks	1

It may be noted that in *Table 2* i.e., assuming a one-day working week or that the components are delivered to the plant in Wrocław on a daily basis, the car is 75% loaded and only 72% of its space load is used.
In a longer perspective it is very unprofitable because as much as 25% of the truck space is not used and besides, it does not exceed a profitability threshold of 85%.
As in the previous case, the results given in *Table 3* do not meet the volume requirements and the cycle

of supply in this case is two weeks, namely 10 working days.

Table 3. Number of shipments and their load for a two-day production

Daily production	1800
Number of working days in a week	2
Production	3600
Percentage fill of a truck	62,22%
Maximum truck tonnage	24000
Gravimetric filling of a truck	69,50%
Necessary number of trucks	2

Table 4. Number of shipments and their load for a three-day production

Daily production	1800
Number of working days in a week	3
Production	5400
Percentage fill of a truck	87,22%
Maximum truck tonnage	24000
Gravimetric filling of a truck	99,53%
Necessary number of trucks	2

Table 4 shows an optimum use of transport capacity. However, in the case of almost one hundred percent use of truck tonnage there is no possibility of adding critical components (if necessary), and therefore there should be two deliveries every three days.

Table 5. Number of shipments and their load for a four-day production

Daily production	1800
Number of working days in a week	4
Production	7200
Percentage fill of a truck	75,56%
Maximum truck tonnage	24000
Gravimetric filling of a truck	88,17%
Necessary number of trucks	3

The value of 88.17% creates favorable conditions to accept this solution. In this case there is also a possibility to load critical components from any of the suppliers which provide the *common components* or from other suppliers, if such an opportunity arises. A full supply cycle should last 4 weeks, three deliveries within every four days.

The situation presented in *Table 6* is not profitable in the long-term use since almost 20% of unused space entails too high costs, which are incurred by Polar in the case of incomplete transport. The advantage of this solution is the length of the supply cycle since it takes one week, which would make the components arrive in the same predetermined manner every week.

Table 6. Number of shipments and their load for a five-day production

Daily production	1800
Number of working days in a week	5
Production	9000
Percentage fill of a truck	69,44%
Maximum truck tonnage	24000
Gravimetric filling of a truck	80,77%
Necessary number of trucks	4

The optimal solution is the variant shown in *Table 4* as filling of the means of transport is almost maximum in this case. What should be adopted in this solution is a three-week supply cycle in which for every three days during which dishwashers are manufactured there must be two deliveries. Such a solution provides significant filling of trucks and accumulation of stock on the third day of production when there is no delivery. It is a fact that such a long supply cycle can sometimes be a problem, but if delivery organization is right, this cycle can significantly reduce the inventory of *common components*.

5. Summary

During the entire analysis of the supply chain and the risks therein, the following hazard-sensitive places have been recognized:

- Whirlpool supply department's ordering quantities needed to carry out production,
- no unforeseen changes in the long-term production plan,
- cooperation with suppliers and their fulfillment of:
  - quantitative
  - qualitative
  - punctuality
  - obligations,
- carriers sticking to deadlines within which they should provide transported components.

During the simulation and optimization of supplies by means of the milk run the best solution has been presented. The main criteria of the solution have been:

- maximizing the use of means of transport,
- minimizing transport cost,
- supply flexibility - regular supplies,
- possibility to minimize inventory,
- preparation for the introduction of the *just in time* method of deliveries,

The most important errors which have been observed include:

- wrong number of parts in the supply,
- supplied parts in unacceptable quality,
- early deliveries,
- unexecuted orders by key suppliers in a situation of shortages of raw materials in stock,
- delays in deliveries caused by both providers and carriers,
- excess of parts in stock and related additional costs of storage.

As a solution to the above problems, we can use the prepared analysis and organize supplies according to the milk run method. The result of this solution are frequent deliveries of small quantities of components needed for on-going production and thus, lowering storage costs. The deliveries would be conducted on time as close cooperation would be established with a carrier which could pick up from various suppliers only the amount that has been ordered and commissioned to receive. Close contact with the carrier means also better guarantee of on-time delivery. As reception of parts would be made several times in one week, continued cooperation with the supplier would be possible even if the supplier production capacity was limited. It would be so since a small amount of collected components would give the supplier the time to produce them before the next delivery. The supply frequency, in turn, would enable the quality department to approve parts upon delivery and to send information to the supplier about unacceptable quality of components and suspension of further acceptance. Thus, risk of incurring additional transport and complaint costs would be greatly reduced.

In the following steps the Whirlpool enterprise can prepare the warehouse and production for the introduction of the just in time method and, above all, focus on the search for new, alternative suppliers located in our country, which would allow a reduction of supply risk related with the key and at the same time problem suppliers. Such an alternative source of supplies would also reduce the bargaining power of these suppliers.

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