Master thesis

Topic: Supply chain sourcing risk management methodology development for N

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Thisthesisdeals with analysis N’ supply chain. Supply chain sourcing risk management methodology development became as the result of analysis. Nowadays supply chain is more vulnerable than ever before, it is related with expanded supply chain. Developed supply chain sourcing risk methodology presents quantitative methods for assessment possibilities of operational risk, and also describes the main preventive strategies on risk response.
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УПРАВЛЕНИЕ ЦЕПЯМИ ПОСТАВОК, УПРАВЛЕНИЕ РИСКАМИ СНАБЖЕНИЯ, SCORMОДЕЛЬ

Данная работа содержит результаты анализа цепи поставок ООО «N». Результатом анализа стала разработка методики по управлению рисками снабжения. В настоящее время цепи поставок имеют достаточно разветвленную сеть, с чем и связаны риски поставок. Предложенная методика по управлению рисками снабжения представляет количественные способы для оценки вероятности операционных рисков, а также описывает основные стратегии реагирования на риски.
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INTRODUCTION

Currently the supply chain is most vulnerable than ever, and the potential impact the effectiveness of the supply chain for the company has never been many-sided. Globalization is one of the reasons that increase the complexity of supply chains and increasing the impact of disruptions to the supply chain exponentially on the number of persons, companies and operations involved in the supply chain of a product or service [16]. Another key factor is the increasing utilization of the extended supply chain (suppliers and customers) [57]. Therefore, adverse effects on at least one of the elements of the supply chain, can lead to a failure along the entire supply chain.

In the context of globalization, competition also increases, along with it, requirements as to profitability, timescales and high level of customer service increase.

The supply chain will be ineffective if we continue to consider the supply chain from the standpoint of planning and operational management of logistics and production, where each company of chain are isolated and planning their needs and sell without coordination with other links of the supply chain. At this stage development of the supply chain arise the term supply chain management. The term supply chain management is reported to first having been used in 1982 by a consultant Keith Oliver of Booz & Company [46].

The supply chain management as a scientific discipline explores the resources of industrial, logistic and commercial companies, as well as decisions made by individuals concerning inter-organizational cooperation processes for the conversion, transformation and use of these resources over the entire supply chain from sourcing of raw materials to the end-consumer.

The supply chain management from a practical point of view is a systematic approach to integrated planning and management of the entire flow of information, materials and services from end-consumer through organizations and warehouses to suppliers of raw materials.

The purpose of production is to increase the flexibility of processes, their efficiency and productivity. The aim of logistics is to provide an industrial production and trade with necessary materials or end-products with inventory optimization (without storage) with reducing logistics costs and improving the level of logistics service. The supply chain management allows integrated achievement these objectives.

For the company implementation of supply chain management means doing business on the principles of strategic cooperation with suppliers and customers. Difference between supply chain management from simple cooperation is information coordination and synchronization of key business processes and models of planning and management based on
common information channels with suppliers and customers throughout the supply chain [1].

As whole the supply chain management currently is in the nature of designing, planning, execution, control and monitoring functions of the supply chain with the objective of creating net value, building a competitive infrastructure, maximize the use of global logistics, synchronizing supply with demand and measuring performance in common. Supply chain is defined as a global network used to deliver products and services, from the extraction of raw materials to the final consumer by means of modeling information, material and financial flows.

For a large company designing of supply chain management system means the transfer of a significant part of both the major (technological) and providing (service) business processes with business partners on a long-term basis.

In countries with developed market economies, the end-product producers receive from "subcontractors" to 70-80% of components having the opportunity to focus on design, processing and assembling technologies, on the creation of new products in other key components. This significantly allows to improve the flexibility of the companyin consequence of increasing multivariance products, to reduce a number of costs associated with the maintenance of own processes.

The use of modern forms of cooperation allows us to focus resources and efforts on areas (core competencies) that determine the competitiveness of products and he entire company. The use of the mechanism of supply chain management has become one of the conditions for industrial growth in the United States, Japan, Germany, Italy, France, Turkey and Southeast Asia.

There are several methods in the field of supply chain management, the main one is Supply Chain Operation Reference model (SCOR) [61].

The SCOR-model was developed by Supply Chain Council. The SCOR methodology currently is recognized as an international industry standard in the planning and management of the supply chain. The main value of SCOR from the point of view of modeling business processes is the availability of standardized business processes in supply chains at different levels of detail, standardized system of indicators for assessing the performance of business processes, identifying data sources for the calculation of performance indicators and information flow in business processes, as well as a description of «best practices» on managing business processes [56].

In this method, the supply chain is described through a combination of ready processes components, therefore, the model can be used to describe the simplest of supply chains and complex networks, using a standard set of process definitions. As a result, incommensurable line of businesses and
individual companies can be easily integrated into the description of the structure practically in any network structure of supply chains. The model allows to describe and to create a basis for improvement of supply chain just as global projects so specific division of the company. The model boundaries are defined «from the supplier’s supplier to the customer’s customer» or rather the model describes the extended supply chain [21].

The most companies spend a lot of time and money to improving performance in the supply chain, applying the traditional method of increasing the efficiency by decrease in assets in the statement of profit and loss, and the first lever for this is the reduction of inventories, work in process and cycles. But if don’t take into account the various risks and uncertainties, this method can cause a huge number of vulnerabilities in the supply chain. No matter how efficient may be the organization’s activities, uncertainties in the supply chain that occur for several reasons, cause various risks of interruptions that have an impact on the sustainability of the supply chain.

According to the survey the Ripple Effect, conducted by Deloitte consulting company, 63% of executives see external suppliers as one of the biggest sources of today’s supply chain concerns [62]. Therefore, responsibility for the disruption’s event remains with the organization, not the suppliers. Moreover, the availability of stand-by suppliers is not secure to preserve the value of the supply chain.

Consistently official data of The Association for Operations Management, 44% of respondents replied that they do not investigate or consider the risks in supply chains, and therefore do not report them to their partners [58]. About one in five reported that they explore the risks and report them to their partners. Risk assessment in supply chains will allow monitoring potential vulnerabilities in interactions with suppliers.

Building reliable mutually beneficial relationships with suppliers is performed as per the procurement process. Also the effectiveness of the implementation of the procurement process has an impact on the achievement of company goals. The procurement process associated with ordering, delivery, receipt and transfer of raw materials, spare parts, products and/or services at a set time, in such number and quality as may be required, as well as the matching fair price.

The share of procurement costs in the revenue of the chemical industry is 61% [2]. Expenses on procurement in N company equal to 65%. Also such responsibilities as customs processing of documents and cargo, transportation of raw materials and equipment in the company is outsourced. Therefore, the result of procurement’s activities is in a large part determined the performance of the company. Another one of the tasks of supply service – manage the process so as to have the minimum required level of inventories. So that two basic indicators of work of the supply chain
are inventory turnover and their level [41]. So the inventory turnover in 2014 decreased by 4.7% in comparison with 2013 which, in turn was 5.4% [19].

In view of the above listed, let's try to adapt the SCOR model by:
- identifying all the processes of the first level required for calculation of the indicators of the functioning of the supply chain;
- decomposition of the source process at subsequent levels - to identify the risks associated with external suppliers, and the calculation of key performance indicators, characteristic for these processes;
- use calculations of the key indicators when assessing the risks and the best practices described in the model as a tool for responding to risks.

In such a way, the aim of master's thesis is to develop the methodology for management of source risks in supply chain for N’ business.
1. THE SUPPLY CHAIN MANAGEMENT

1.1. The concept of supply chain and supply chain management

A commonly accepted definition of supply chain does not exist. Supply chain is defined differently by different authors, but the essence generally stays the same. According to the accepted separation of supply chain on object-based and process-based understanding is given below definition of supply chain:

Supply chain (process-based understanding) is a set of flows and the corresponding cooperation and coordination processes between the various participants in the value chain to satisfaction the requirements of consumers for goods and services.

Supply chain (object-based understanding) is an aggregate of organizations (manufacturers, warehouses, distributors, 3PL and 4PL providers, freight forwarders, wholesale and retail trade), interacting in the material, information and financial flows, and the flows of services from sourcing of raw materials to the end-consumer.

The APICS Dictionary [7], the Educational Society for Resource Management, has one of the better definitions and defines «supply chain» as:

«The processes from the initial raw materials to the ultimate consumption of the finished product linking across supplier-user companies. The functions inside and outside a company that enable the value chain to make products and provide services to the customer». And other definition is:

«A group of companies connected loosely, all collaborating on the same goal: efficient and economical product delivery. Or, the set of order-entry-and order-fulfillment-related physical interactions connecting a company and its customers and suppliers».

According to APICS Dictionary [7]: Supply Chain—the global network used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash.

Supply Chain Management - the design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally.
1.1.1. Basic elements of supply chain

The main elements of the supply chain are supply chain participants:
- suppliers of raw materials,
- sub-suppliers,
- focal company (manufacturer of final products or services),
- distributors,
- customers. On figure 1 is presented the elements of the supply chain [1].

![Diagram of the supply chain elements](image)

**Figure 1. The main elements of the supply chain.**

Supplier of raw materials is any legal entity (organization, company, institution) or individual that supplies raw materials for the production of goods or services.

Sub-suppliers - an organization retained by the focal company for providing services [1].

The focal company integrate and manage process links with first-tire customers and suppliers, although it may be actively involved in the management of other process links beyond the first tier [30]. The focal company might also participate in the product development process of a key customer [63].

Classically, distributor refers to the channel entities that act as intermediaries between manufacturers and end-use customers [45]. The APICS Dictionary [7], describes a distributor as «a business that does not manufacture its own products but purchases and resells these products» distributor may stock and sell a full range of items from different manufacturers [40].
Customers are the common name of the subject, using some services (retailers, dealers, end-users).

Elements of the supply chain are connected with information, financial and material flows. Materials flows are the physical products, raw materials, suppliers, and so forth that flow along the chain. Material flows also include reverse flows—returned products, recycled products, and disposal of materials or products. Information flows consist of data that are related to demand, shipments, orders, returns, and schedules, as well as changes in any of these data. Finally, financial flows involve money transfers, payments, credit card information and authorization, payment schedules, e-payments, and credit-related data [43].

Special features of supply chain first of all are:

- legal independence of chain participants and their competition with each other and with other supply chain
- the presence of a focal company, i.e. the manufacturer of the final product or service (OEM – Original Equipment Manufacturer) in manufacturing, trading network to trade or logistics provider,
- cooperation and coordination relations with suppliers and customers.

These features along with a number of advantages about reducing costs, increasing flexibility of supply and market's requirements consideration, also caused a number of new problems. These include, primarily:

- decision making by managers from different independent the focal company organizations, which cause increasing risks due to the competition between enterprises, a large number of actors in the supply chain, linkages between them and with the external environment,
- increased dependence on suppliers and customers,
- the appearance of new types of costs.

For a large company designing of supply chain management system means the transfer of a significant part of both the major (technological) and providing (service) business processes with business partners on a long-term basis. For many Russian industrial enterprises is as yet in a great measure characterized by having the closed cycle of production. This allows to provide their own production programs, but economically inefficient in terms of working on the open market. In this regard, it is necessary to develop the competencies that are most effective [1].

The totality of the decisions made during the supply chain management can be divided into levels of configuration of the supply chain (strategy), implementation planning processes in the supply chain (tactics) and operational management of the supply chain. Table 1 presents the main stages of decision making in the supply chain management [49].
Strategic-level planning involves the supply chain network design which determines the location, size and optimal numbers of suppliers, the production plant and distributors to be used in the network.

Table 1 - Main levels of decision making in supply chain management [1]

<table>
<thead>
<tr>
<th>Levels of decision making</th>
<th>Initial data</th>
<th>Objectives of supply chain management</th>
</tr>
</thead>
</table>
| Strategic plan (several years) | Marketing plans  
Financial plan  
Strategy of competitive behavior  
Form of the supply chain’s organization | The development of the strategy and objectives of the supply chain (SC);  
The choice of organization form SC  
Designing the network structure of the supply chain;  
The selection of suppliers and system of interaction with them |
| Tactical plan (3 months-1 year) | Structure of suppliers in the supply chain  
The structure of the SC capacity | Demand forecasting  
Production program planning and inventory  
Distribution planning, transportation, production and procurement |
| Operational plan (1 day-1 week) | The demand forecast  
Production program  
Plans of distribution, production and procurement | Planning of production schedules  
Routing of vehicles |
| Process implementation | Actual data on implementation processes | Monitoring the supply chain  
Reconfiguration and adaptation |

The tactical level of supply chain management covers the planning of suppliers, manufacturing schedules and the forecasting of demand [51].

The operational level of supply chain management focuses on day-to-day operations and enables efficiencies in production, distribution, inventory and transportation. Operation planning system include the following factors: demand planning, production scheduling, inventory and transportation planning [49].

1.1.2. The Supply Chain Operations Reference model

The Supply Chain Operations Reference model (SCOR-model) has been developed to describe the business activities associated with all phases of satisfying a customer’s demand. The model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return (shown in Figure 2) [9]. By describing supply chains using these process building blocks, the Model can be used to describe supply chains that are very simple or very complex using a common set of definitions. As a result, disparate industries can be
linked to describe the depth and breadth of virtually any supply chain. The model has been able to successfully describe and provide a basis for supply chain improvement for global projects as well as site-specific projects [64].

![SCOR Diagram](image)

Figure 2. SCOR is organized around five major management processes [20].

The SCOR model has a four-level structure; they are shown in figure 3. The first level covers five basic management processes in the supply chain as follows [18]: plan (all preparatory activities for the process, the identification of resources, the requirements pooling of supply service, production and placement, scheduling of using capacities, including to the extent of ordering), source (description of procurement, receiving, verification and transportation of incoming materials processes), production (all production processes, starting with the requirements for raw materials and its receipt, the production itself up to assembly and packaging), delivery (demand define, order management and the sales process, including warehouse and transportation management) and reverse flow (return) [1].

These basic processes are described in more detail at the following levels. So, on the second level there is differentiation across 30 categories, «standard processes», then on the third level are configured using a process based on industry standard recommendations. SCOR model allows defining the processes in the supply chain at the operational level in terms of limited private flows and document both as the temporal and logical sequence of production cycles of order fulfillment so operational base values. In this form of visual processes constitute the basis for understanding the partners and provide an opportunity for analysis of such factors as time and costs.

SCOR is a descriptive model that allows the company to implement a structured entry into the project of creating a supply chain (level 1), to simulate present and future supply chain on business processes level and provide a comparison of each element with benchmarking data (levels 2/3),
and also to prepare the basis for the implementation of processes by using specific IT [1].

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Schematic</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Top Level (Process Types)</td>
<td><img src="chart1" alt="Plan Schematic" /></td>
<td>Level 1 defines the scope and content for the Supply-Chain Operations Reference Model. Here the basis of competition performance targets are set.</td>
</tr>
<tr>
<td>2</td>
<td>Configuration Level (Process Categories)</td>
<td><img src="chart2" alt="Plan Schematic" /></td>
<td>A company’s supply-chain can be “configured-to-order” at Level 2 from core “process categories.” Companies implement their operations strategy through the configuration they choose for their supply-chain.</td>
</tr>
<tr>
<td>3</td>
<td>Process Element Level (Decompose Processes)</td>
<td><img src="chart3" alt="Plan Schematic" /></td>
<td>Level 3 defines a company’s ability to compete successfully in its chosen markets, and consists of:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Process element definitions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Process element information inputs, and outputs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Process performance metrics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Best practices, where applicable</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• System capabilities required to support best practices</td>
</tr>
<tr>
<td>4</td>
<td>Implementation Level (Decompose Process Elements)</td>
<td><img src="chart4" alt="Plan Schematic" /></td>
<td>Companies implement specific supply-chain management practices at this level. Level 4 defines practices to achieve competitive advantage and to adapt to changing business conditions.</td>
</tr>
</tbody>
</table>

Figure 3. SCOR Process Decomposition Model [10].

SCOR has been widely presented in the literature [12]. Without repeating these materials, let’s analyses the SCOR advantages and disadvantages. The main value of SCOR from the business process modeling point of view is the standardized business process that are interlinked at three levels [23], standardized system of indicators for assessing the performance of business processes, identifying data sources for the calculation of performance indicators and information flow in
business processes, as well as a description of «best practices» on managing business processes.

The disadvantages of SCOR should be attributed primarily focus on private enterprise as the object of modeling, instead of the whole supply chain, as well as modeling limitation on the processes of planning and implementation of the «ideal» processes (non-availability of phase control and changes), along with consideration mainly the transport and logistics preparation and post-production operational and service stages. It should also be noted that the fourth level of business processes – in fact their implementation, are outside the SCOR model.

In the SCOR model to assess the performance of the supply chain conditionally apply two kinds of indicators:

I. The performance of the chain (Performance Attributes) – grouped metrics used to establish strategies in the supply chain. By themselves, the performance indicators can't be measured, they only specify the direction of the strategy. In the SCOR model separate 5 groups of indicators – aspects of the supply chain performance [12]:

1. Supply Chain Reliability – the performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer. Another words the ability to perform tasks as expected or planned [28].

2. Responsiveness of supply chain (the duration of the logistic cycles) - the passage’s rate of goods through the supply chain to the consumer. The speed at which tasks and activities are performed [38].

3. Supply Chain Agility (flexibility) - the time at which the supply chain responds to marketplace changes to gain or maintain competitive advantage [48].

4. Supply Chain Costs – the costs associated with operating the supply chain [64]. This includes labor costs, material costs, management and transportation costs.

5. Supply Chain Asset Management – the effectiveness of an organization in managing assets to support demand satisfaction. Asset management strategies in a supply chain include inventory reduction and insourcing vs. outsourcing.

II. Metrics (the system of measurable indicators) are designed to assess the achievement of the strategic decisions outlined in the terms of performance of the supply chain. It's an established standard for assessing the activity or process. The SCOR metrics are used to detect problems in the supply chain. The SCOR model identifies three levels of metrics (groups of indicators):

Level 1 contains the indices of diagnosing the overall condition of the supply chain. Also known as strategic metrics or key performance
indicators (KPI - Key Performance Indicator). A comparative analysis of indicators of the first level helps in setting real targets and objectives for the chosen strategic direction.

Level 2 includes indicators which in turn are diagnostic metrics for the first level and help to identify the causes of deviations in the scheduled values.

Level 3 contains indicators that respectively serve to diagnose the causes of deviations of the metrics of the second level.

All metrics from the first to the third level of the SCOR model have hierarchical structure and reflect the state of the process corresponding decomposition level. Decomposition helps to identify the factors contributing to deviation from target values, which are subject to more detail investigation.

1.2. The supply chain elements of N

N is the market and price leader in the Nordic countries, Russia and the CIS countries, and also one of the most fast-growth players at the premium tire market in the countries of Central Europe. The company is expanding its market share in Russia and CIS countries due to the distribution expansion and high brand awareness. N also increases its presence in the Northern and Central Europe markets, in particular in the winter tires for passenger cars segment, as well as in segments of winter and summer tires for SUVs [37].

The company is engaged in the production 3 categories of tyres (PC1, PC2, PC4). The production is performed by capacity of the two plants, which are located in the N (Finland) and Vsevolozhsk (Russia) cities. The plant in Vsevolozhsk is engaged in the manufacturing tires for passenger cars and SUVs (PC1), as well as loading ex works from Finland, China and Spain industrial tires (PC4) and truck tyres (PC2). Winter tires are produced at the plant all year round, but summer tires are produced in summer. The tiers are sold in replacement markets. The main markets are the Nordic countries, Russia and the other CIS countries, the rest of Europe and North America.

The N Passenger Car Tyres unit develops, manufactures and markets summer and winter tyres for passenger cars, SUVs and vans. The key products are studded and non-studded winter tyres, SUV tyres and high-speed summer tyres, which are the fastest growing product segments and also have the best margins in the tyre business. N’s most important brands are NHakkapeliitta, N Hakka and NNordman. In 2013, winter tyres represented 79% of N passenger car tyres’ sales volume. In 2014, 80% of all passenger tires manufactured by the group were produced at the Russian plant in Vsevolozhsk [6]. The tires produced at this plant are sold in Russia
and are exported to 43 countries, including Finland, Sweden, Norway, Germany, USA and Canada.

N Heavy Tyres focuses on high-quality special tyres. The key product groups are forestry tyres, harbor and mining tyres, special agricultural tyres, a variety of industrial tyres as well as truck tyres and retreading materials for demanding conditions. The unique qualities of the products grow out of the knowledge of extreme operating conditions and respect for nature.

The high-quality truck tyres are developed in Finland and manufactured as outsourced contract manufacturing in factories whose level of quality meets N’ high standards. Retreading materials, which are mainly used in truck tyres and machinery tyres, are manufactured at our factory in N. A restructuring of the Heavy Tyres operation to include also the Truck Tyre business unit was done in the end of 2013 and the new organization became effective from the beginning of 2014, creating synergies in all operations.

The company's strategy is focusing and profitable growth. The one area of focusing is products and services that facilitate safe transportation in northern conditions [36]. So to maintain its reputation as the best manufacturer of winter tyres, the company pays great attention on research and development. New technologies, innovations developed by a group of researchers pass detailed laboratory studies to determine the impact on the main performance of the tyres (safety, wear resistance, rolling resistance, handling on wet road and noise level when driving) and testing in the proving grounds. The company also cooperates with leading researchers to develop and use more technologically advanced, economical and environmentally-friendly materials (development of new types of synthetic rubber, silica).

The company encourages feedback from consumers related to product quality to create value in the supply chain to end-customers. Specifically professional technical group collect and analyses consumers' complaints related to product quality, as well as applications of end-customers, where it possible and appropriate, analyses the degree of customer satisfaction, if available, and the end-customer. Customer’s requests in the form of complaints, responses are recorded, processed by this technical support and work with claims group. By results of consideration of which it appears the cause of the defect and the level of customer satisfaction [4].

Also by understanding market requirements we can plan our strategic decision connected with resources and processes. Table 2 shows performance objectives [53] for tyres, adapted to N business.
<table>
<thead>
<tr>
<th>Performance objective</th>
<th>QQ/OW</th>
<th>From customer point of view</th>
<th>From company point of view</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>Order-winner (OW)</td>
<td>Wear-resistance Safe driving in any weather Reduced rolling resistance and good handling on the track Low level of noise</td>
<td>Use only high-quality materials The purchase raw materials from approved suppliers Multi-stage quality control</td>
<td>The number of claims Number of returns</td>
</tr>
<tr>
<td>Brand</td>
<td>Order-winner (OW)</td>
<td>Safety Comfort</td>
<td>Safe and environmentally friendly tires for winter conditions</td>
<td>The number of wins in tests</td>
</tr>
<tr>
<td>Speed</td>
<td>Order-qualify (OQ)</td>
<td>Product availability on replacement market</td>
<td>Lead time from order to delivery Lead time to response on return</td>
<td>Delivery Cycle time Return Cycle time</td>
</tr>
<tr>
<td>Dependability</td>
<td>Order-qualify (OQ)</td>
<td>Wideassortiment</td>
<td>Deliveryon-time</td>
<td>Percentage of deliveries’ on time, in full The number produced standard series</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Order-qualify (OQ)</td>
<td>The availability of products in all regions and cities The ability to order on the official website of the company</td>
<td>Innovations in development Cooperation with research centers of Japan (testing new types of rubber), with opportunity testing in the proving grounds The increasing capacity of production Wide distribution</td>
<td>Number of orders made through the online shopping The lead time to cover orders; The produced volume The number of new products (expansion of the range)</td>
</tr>
<tr>
<td>Cost</td>
<td>Order-winner (OW)</td>
<td>Expensive premium products Product with average price tier</td>
<td>The costs of research and development</td>
<td>Price of product Price of raw materials</td>
</tr>
</tbody>
</table>

The main tire’s raw components are both natural and synthetic rubber (polymers), soot (carbon black) and oil (plasticizer). The share of rubber compounds in the tire - more than 80%. The remaining parts of components are ruggedizing the design or the construction of the tyre. Approximately half of the used rubber is a natural raw material extracted from rubber tree. Rubber tree is cultivated in countries with tropical climate such as Malaysia and Indonesia, raw materials are supplied to the ports of
Finland. Further, the rubber is transported into storage at a warehouse in the city of N, which is used in the factories of N and Vsevolozhsk. Most of the synthetic rubber produced from petroleum, the company receives from European manufacturers. Because of the expected increase in demand for tires, may experience a shortage of natural rubber. The main component of synthetic rubber – butadiene, which is a by-product of oil refining, is also at risk of deficiency. Approximately one third rubber compound fillers. The most important of them – carbon, due to which the tyre is black. The second important filler – oil, it plays the role of a rubber softener mixture. In addition, in the production of rubber compounds ingredients are used for the vulcanization of rubber and other chemicals. Table 3 shows the group of materials and raw materials used for the production of tires, and the country of supply. 35% of providers operate in the FCA, to 28% - DDP and DAP, the other under CIF and FOB.

Table 3 – Raw materials and groups of materials for the production of tires

<table>
<thead>
<tr>
<th>Rawmaterial/materialgroup</th>
<th>Supplier's countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>CarbonBlack</td>
<td>Russia (Yaroslavl, Omsk), Germany, Ukraine</td>
</tr>
<tr>
<td>Activators</td>
<td>Russia (Rostov-on-don, Moscow), Sweden, Belgium, Germany, Italy</td>
</tr>
<tr>
<td>Steelcords&amp;beadwires</td>
<td>Belarus, Russia (Lipetsk)</td>
</tr>
<tr>
<td>Crosslinking agents</td>
<td>Russia (Moscow), Italy, Belgium, India</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>Russia (Nizhny Novgorod, Moscow), Finland</td>
</tr>
<tr>
<td>Retarders/ Accelerators</td>
<td>Italy, China, Spain, Sweden, Belgium, Germany, Russia (Novocheboksarsk)</td>
</tr>
<tr>
<td>Antioxidants</td>
<td>Russia (Novocheboksarsk), Germany, Belgium, Sweden, Italy</td>
</tr>
<tr>
<td>Paints</td>
<td>Germany, Italy</td>
</tr>
<tr>
<td>Polymers</td>
<td>Russia (Moscow, Sterlitamak), UK, Switzerland, France, Belgium, Poland, Czech Republic</td>
</tr>
<tr>
<td>Accessories</td>
<td>Russia (Saint-Petersburg, Vsevolozhsk)</td>
</tr>
<tr>
<td>Anti-tackagents</td>
<td>Russia (Samara), UK</td>
</tr>
<tr>
<td>Fillers</td>
<td>Germany, France, Finland</td>
</tr>
<tr>
<td>TyreCordFabrics</td>
<td>Czech Republic, Korea</td>
</tr>
<tr>
<td>Resins</td>
<td>France, Belgium, Germany, Italy</td>
</tr>
</tbody>
</table>

The concern N has an extensive distribution in many countries of the world. Trading companies operating in Russia, Kazakhstan, Belarus, Ukraine, Finland, Sweden, Norway, Germany, Switzerland, Czech Republic
and USA. In other countries the group's products are submitted to independent importers. So the distribution represented about 10 major dealers, retail companies - replacement market through a network of tire centers Vianor (1,355 stores in 27 countries, increase of 149 stores in 2014), NAD (N Authorized Dealers) (896 stores in 14 Central European countries and China, increase of 437 stores in 2014), N-Tyre (53 stores in Russia and Kazakhstan). Also sales through online stores (mainly tires premium) and automakers.

Important for the company the opinion of consumers, so in all sales channels working with feedback and evaluation of consumer's satisfaction where possible. Feedback is through the collection and analysis of consumer complaints related to the quality of the company's products, as well as complaints, feedback from the end users where possible.

For distributors are important price, availability of desired sizes, the speed of response to requests. Also in the countries of the European Union on the tires must have a marking indicating the level of noise, handling on wet road, fuel consumption. The speed of response to the request for a long period, discusses options for its reduction. Currently distributors in Russia, basically implement tires middle segment (brand Nordman), so when deciding on the number of shipments in this segment, distributors put a condition, the requirement to sell a certain amount of premium tires (brand hakkapelitta). Also large distributors in Europe and the U.S. the company carries out orders for the production of tires under the brand names of distributors.

Through the official online store that sell tires directly to the ultimate purchaser. There are also a number of recommended online stores that provide Hakka Guarantee.

Cooperation with car manufacturers while in small quantities, because the tires of the concern is designed for vehicles in the premium segment. And for automakers are important the price to lower which is required or the change in technology the entire production cycle, but it is not possible, because the tires in terms of quality starts to fall, or need to implement a new separate production line to produce tires with the use of cheap raw materials. Figure 4 presents the logistic network of the company AS-IS.

1.3. SCOR-model as the base model of the organization of supply chain management, the application of this model for business N

Production of tyres for passenger cars is one of the main directions of development of business of the group. Despite the crisis in 2014 there
was an increase of 2.6% in this segment, the share of revenue accounted for 79% of total revenue for the group by results 2014.

Based on an analysis of the company and the description of the elements of the supply chain SCOR model is applicable for this segment. To understand the state of the supply chain at the strategic level it is necessary to calculate the performance of the supply chain.

The performance indicators are divided into two categories of external (customer-oriented) and internal (focused on business processes). To calculate which will require data of procurement processes, delivery, production and returns in the aggregate. Therefore, Table 4 shows only the formula to calculate the characteristics of the strategic status of the supply chain.

To calculate the reliability is necessary order information. The order is considered perfect when all the order parameters are implemented in full. So the order of line, packing materials/material is checked at the time of acceptance of the goods-statistic should be requested from warehouse group. Deviation from the expected delivery date can be verified according to the Oracle ERP system. The correctness of filling the accompanying documentation as a customs declaration, the specification is carried out in advance of the shipment, which helps identify errors and inaccuracies in the filling. So the number of detention orders related to the documentation can be checked on the information available to the customs clearance specialists.
Table 4 – The performance attributes (PA) of the supply chain

<table>
<thead>
<tr>
<th>PA</th>
<th>Level 1. KPI (code)</th>
<th>Definition</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Perfect Order Fulfillment</td>
<td>The percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damage. Components include all items and quantities on-time using the customer’s definition of on-time, and documentation – packing slips, bills of lading, invoices, etc.</td>
<td>[Total Perfect Orders] / [Total Number of Orders] x 100%</td>
</tr>
<tr>
<td></td>
<td>(RL.1.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsiveness</td>
<td>Order Fulfillment Cycle</td>
<td>The average actual cycle time consistently achieved to fulfill customer orders. For each individual order, this cycle time starts from the order receipt and ends with customer acceptance of the order.</td>
<td>[Sum Actual Cycle Times For All Orders Delivered] / [Total Number Of Orders Delivered]</td>
</tr>
<tr>
<td></td>
<td>Time (RS.1.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agility</td>
<td>Upside Supply Chain</td>
<td>Number of days an organization requires to achieve an unplanned sustainable 20% increase in quantities delivered</td>
<td>The calculation of supply chain flexibility requires the calculation to be the least time required to achieve the unplanned sustainable increase when considering Source, Make, and Deliver components.</td>
</tr>
<tr>
<td></td>
<td>Flexibility (AG.1.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Upside Supply Chain</td>
<td>Amount of increased production an organization can achieve and sustain in 30 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adaptability (AG.1.2)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Downside Supply Chain</td>
<td>Reduction in quantities ordered sustainable at 30 days prior to delivery with no inventory/ penalties</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Adaptability (AG.1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Cost</td>
<td>Total Supply Chain</td>
<td>The sum of the costs associated with the SCOR Level 2 processes to Plan, Source, Deliver, and Return.</td>
<td>Sales – Profits – Cost to Serve (e.g., marketing, selling, administrative)</td>
</tr>
<tr>
<td></td>
<td>Management Cost (TSCMC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(CO.1.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost of Goods Sold (COGS)</td>
<td>The cost associated with buying raw materials and producing finished goods. This cost includes direct costs (labor, materials) and indirect costs (overhead).</td>
<td>direct material costs + direct labor costs + indirect costs related to making product</td>
</tr>
<tr>
<td></td>
<td>(CO.1.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If it's raw materials, it passes through the input control, getting in stock in quarantine. Further, each batch of raw material is checked for compliance according to certain indicators. The deviation from the norms of one of the indicators does not lead immediately to return of materials. The production can change the recipe, in case of non-conformity of raw materials to the norm stated in the specification, but before using this raw material requires approval from research and development department in N's global office. Therefore it is recommended to consider the order to be fulfilled if the raw material complies with the all stated requirements of the specification, without changing the recipe.

If the ordered equipment, compliance with the terms of the order after delivery is controlled by the responsible of the production department. Therefore statistics on the implementation of the order must be requested at the head of the production department.

After collecting all the information on the orders, each order is necessary to compare all the above parameters and calculate the percentage
of perfect order fulfillment. If the value of calculation will higher, the reliability of the supply chain is high.

Calculating the response time of the supply chain need to know the amount of time spent on the execution of the order, starting from the moment the order was placed before the date of the order. It should be taken into account even the time during which the order was not processed. So to calculate the Order Fulfillment Cycle Time by suppliers of raw materials we use data from the ERP system ORACLE. The Order Fulfillment Cycle Time is calculated as the difference between «Actual date» and «Order date». Table 5 presents the calculation of Order Fulfillment Cycle Time for suppliers of raw material - carbon black. The Order Fulfillment Cycle Time equal to average time to fulfill the order.

Table 5 – Calculation of Order Fulfillment Cycle Time, days

<table>
<thead>
<tr>
<th>Provider</th>
<th>The sum of days spent on the execution of all orders</th>
<th>The total number of orders made by the supplier</th>
<th>Average time to fulfill the order, days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>372</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1735</td>
<td>45</td>
<td>39</td>
</tr>
<tr>
<td>Russia (1)</td>
<td>14359</td>
<td>331</td>
<td>43</td>
</tr>
<tr>
<td>Russia (2)</td>
<td>11281</td>
<td>256</td>
<td>44</td>
</tr>
<tr>
<td>Total for all suppliers</td>
<td>27747</td>
<td>644</td>
<td>43</td>
</tr>
</tbody>
</table>

The measure Supply Chain Agility metric’s need to understand that the downside and upside refer to the direction of the demand change [55]. When demand increase, it is upside; when demand decrease, it is downside. Flexibility is to measure the number of days it takes to respond to a demand change, while adaptability is to measure the maximum quantity of production change the organization can achieve and sustain in a fix amount of time.

Changes in demand affect the supply chain, and cause them to be more flexible. So the change in demand for tires puts the company cooperate with the suppliers, which must have a sufficient stock of raw materials and the opportunity to deliver urgently in the case of increased demand. And to meet the company in case of reduction in demand for tires, therefore, the demand for supplied raw materials.

Actual values of the performance attribute should be compared with planned, with the average value of the industry, with competitors and with leader. Further the find out deviations of performance attribute necessary to expand by the components metrics of the second and the following levels associated with «process types».
Using the description of the 2 level SCOR-model «process types» will construct the flow diagram of the supply chain. Figure 5 shows a flow diagram of the supply chain for the production of tyres for passenger cars.

![Flow Chart for Supply Chain](image)

Figure 5. A flow chart «AS-IS» supply chain of N for the segment of passenger car tires - processes in the implementation of SCOR model

Focal company (FC) is represented by a plant located in Vsevolozhsk (Russia). Due to the fact that one of the four focus areas of the company's strategy is the effective distribution, and the importance of having the necessary size and brand of tyres, on-time delivery to the consumer requires the availability of finished products in the warehouse. Therefore, the company's production strategy is «make-to-stock». This process in the SCOR model is coded as M1. Suppliers in relation to FC perform a process of sourcing raw materials. Distribution channels receive finished goods from warehouses of FC, but company with car manufacturers and some distributors work «make-to-order» statement. So, for example, working with car manufacturers, in addition to the production of tyres it is necessary to carry out the installation of tires with wheels of car manufacturers; to some distributors need to produce tyres under the name of their distribution network. Logistics operators submitted by third-party transport companies delivery of raw materials and finished products. Relationship with raw material suppliers in SCOR model is characterized by the process source. Source processes include activities such as:
- Material acquisition (to obtain, receive, inspect, hold and issue material);
- Vendor certification and feedback, sourcing quality, in bound freight, vendor contracts and initiate vendor payments;
  - Raw materials warehouse management;
  - Raw materials transportation (to manage traffic, manage inbound freight);
  - Manage source business rules;
  - Manage raw materials transportation.

At the next level, we divide the source process on sub-processes according to the third level of SCOR model. Description of the sub-processes of the third level is necessary to further identify the risks of source and identify the consequences for other sub-processes. Sub-processes of S1 shown in table 6 with indicating input and output sub-processes belong under to company.

As shown in table 6 there are 5 major sub-processes of source. They are all bounded with another type of processes.

The process of source in the company is carried out by the purchasing department and logistics. Specialists of the department of Logistics and Purchasing are collecting and processing of generalized and consolidated with the requests by the department requestor, form and carry out maintenance plan for the procurement of goods, works and services, provide a list of suppliers, maintain registers of contracts, keep records of the procurement and report to regulatory authorities. Purchasing and Logistics department at the same time refers to the two companies, one of them produce tyres, another sales. And in this two companies department plays key role as source all departments with required goods and services for creating value along supply chain. The structure of Purchasing and Logistics department is divided into groups: purchasing, logistics, planning and customer service (Appendix A).

The planning department is the link between the sales department and the production department. Planning production plan depends on the planned volume sales, which account for a planning horizon of one year. During the year, depending on the pre-entering customer orders specifying certain types of tires, the data are corrected with the update for one week. Depending on this, also have to adjust the volume of the ordered raw materials. Production capacity regardless of what the tire type size produce - constantly loaded. All finished goods are sent to the warehouse of finished products by region for shipment and temporary storage.

The procurement process is represented globally in N and locally by the Purchasing and Logistic division in Russia. Responsibilities of global procurement at N: the relationship with suppliers, signing contracts for two
plants, selection/approval of new suppliers, evaluation/audit of suppliers. Local purchasing office in Russia is engaged assessment of quality.

Table 6 - Input and output processes in the sub-source SCOR model

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Sub-source processes</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replenishment Signal sM1.2, sD1.3</td>
<td><strong>sS1.1.Schedule Product Deliveries</strong> (Scheduling and managing the execution of the individual deliveries of product against an existing contract or purchase order. The requirements for product releases are determined based on the detailed sourcing plan or other types of product pull signals.)</td>
<td>Product On Order sES.10</td>
</tr>
<tr>
<td>Return Inventory Transfer Data sDR1.4</td>
<td><strong>sS1.2.Receive Product</strong> (The process and associated activities of receiving product to contract requirements)</td>
<td>Scheduled Receipts sS1.2, sM1.1, sD1.8</td>
</tr>
<tr>
<td>Supplier Performance sES.2</td>
<td><strong>sS1.3.Verify Product</strong> (The process and actions required determining product conformance to requirements and criteria.)</td>
<td>Receipt Verification sS1.2, sS1.3</td>
</tr>
<tr>
<td>Logistics Selection sES.6</td>
<td><strong>sS1.4.Transfer Product</strong> (The transfer of accepted product to the appropriate stocking location within the supply chain. This includes all of the activities associated with repackaging, staging, transferring and stocking product. For service this is the transfer or application of service to the final customer or end user)</td>
<td>Existing Inventory Data sES.4</td>
</tr>
<tr>
<td>Production Schedule sM1.1</td>
<td><strong>sS1.5.Authorize Supplier Payment</strong> (The process of authorizing payments and paying suppliers for product or services. This process includes invoice collection, invoice matching and the issuance of checks)</td>
<td>Transferred Product sS1.5</td>
</tr>
<tr>
<td>Product sD1.13</td>
<td></td>
<td>Finished Product Release sD1.8</td>
</tr>
<tr>
<td>Defective Products sDR1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduled Receipts sS1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receipt Verification sS1.2, sS1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product Inventory Location sES.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replenishment Signal sM1.2, sD1.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transferred Product sS1.4</td>
<td></td>
<td>None identified</td>
</tr>
</tbody>
</table>
Approval of new suppliers of raw materials takes place in three categories:

- Product approval process by specialist of R&D;
- Supplier approval as a company by procurement (Global procurement in N); evaluation by global buyer (Purchasing Manager/Officer) under evaluation criteria (ISO 9001(request); code of conduct (request), ISO 14001; ISO TS 16949; reputation and track record; capacity and delivery reliability; risks (country related, ownership; availability, etc.); environmental protection attitude; social responsibility; REACH regulation (Registration, Evaluation and Authorization of Chemicals) status for chemical suppliers (request if applicable), financial viability; costs (price, logistics costs, payment terms).
- Documents (ISO certificates, supplier self-questionnaire, supplier approval form, code of conduct).

Current supplier evaluation includes next points:

- Receiving quality control (responsibility of R&D; CoA with each delivery – check – approval – accepted for use; sample from each delivery – min visual check; measurement at random frequency);
- Audits by procurement (N global procurement). 5-7 supplier audits per year (strategic importance, availability risks etc). For stud suppliers, more thorough audit by R&D.
- Supplier classification: criticality, volume, divided into 5 groups, which present in figure 6.
- Annual performance evaluation (delivery accuracy (deliveries on-time/all deliveries on both factories – percentage rate); quality (deliveries without defection/all deliveries on both factories – percentage rate); subjective by responsible buyer: service (1/2/3 points); reliability (1/2/3 points); R&D support (1/2/3 points); in total 3-9 points – percentage rate out of 9
- ISO certificates: ISO 9001 50%; TS 16949 80%; ISO 9001 and 14001=80%; TS 16949 and 14001=100%
- Delivery control (continuous process by import forwarding department)
The local purchasing department works according to the policy on procurement [3]. This policy defines the process of procurement in the company. The main objective of the is to organize an effective procurement process, allowing for the purchase of inventory, goods and services on the most favorable conditions for the company, to minimize risks and implement procurement control over the company. Also, the policy determines the allocation of duties and responsibilities of employees involved in the procurement process, and apply to any purchases, which are carried out by employees.

Purchasing of goods and services in the company are divided into 4 types:

- the purchase of the competence of the purchasing group;
- common (joint) purchasing for the company with divided responsibility between the participants;
- the purchase of the competence of the authorized buyers;
- non-standard purchases (procurement of finished products (tires) and commodity (production) materials at the company's headquarters; the purchase from monopolists; transport and forwarding services for the delivery of finished products to customers and interdepot transfer, as well as raw materials from suppliers; samples for testing, including competitor tyres).

Purchasing group is responsible for the acquisition from third parties of goods and services
- directly related to the production process / direct (raw materials: natural and synthetic rubbers, fillers (carbon black, silica, etc.), industrial

<table>
<thead>
<tr>
<th>B2, bottleneck suppliers</th>
<th>A, strategic suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Low/significant volume</td>
<td>- Large volume</td>
</tr>
<tr>
<td>- Availability risk</td>
<td>- Limited number of</td>
</tr>
<tr>
<td>- Only one approved</td>
<td>- potential suppliers</td>
</tr>
<tr>
<td>- Limited number of</td>
<td>- on the market</td>
</tr>
<tr>
<td>- potential suppliers on</td>
<td>- Difficult to</td>
</tr>
<tr>
<td>- the market</td>
<td>- substitute</td>
</tr>
<tr>
<td>- Difficult to substitute</td>
<td>- Strategic importance</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C2, routine suppliers</th>
<th>C1, routine suppliers</th>
<th>B1, volume suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Low volume</td>
<td>- Significant volume</td>
<td>- Large volume</td>
</tr>
<tr>
<td>- Good availability on</td>
<td>- Good availability on</td>
<td>- Limited number of</td>
</tr>
<tr>
<td>- the market</td>
<td>- the market</td>
<td>- potential suppliers</td>
</tr>
<tr>
<td>- (0.5 M€)</td>
<td></td>
<td>on the market</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Availability risk, replaceability</th>
<th>Purchasing volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Figure 6. Classification of suppliers of raw materials N.
oils and lubricants for production; metal cords and board wire; textile cords; chemical additives; studs; packaging materials, labels for marking tire and wheel assembly, balancing weights, other goods included in the formulation of finished product or used in the process of production of finished products),

- and others goods and services / indirect (spare parts for equipment, chemicals, clothing, laboratory equipment and accessories, technical gas, fuel for industrial needs, delivery of office supplies, furniture, items for information services (personal computers, copiers and fax machines, printers, mobile phones, ink cartridges etc.); minor production equipment (including installation and commissioning); main production equipment purchased as part of the budget of the plant expansion (according to the instructions of the head office), goods and services related to non-production materials.

Purchasing group for general (joint) purchasing carries out a competitive selection of a supplier and enters into a contract for the supply of goods and services. Placing purchase requisition (PR) and purchase order (PO) is in the competence of the authorized purchaser - responsible employee of the company who is not a member of purchasing group, which were handed over authority for the purchasing of goods and services.

Purchases within the competence of authorized purchasers are carried out by authorized buyers of various departments / groups. Heads of departments can attract a group of purchasing for providing assistance in conducting the competitive selection of suppliers and tender procedures. For example, the department of logistics and purchasing carried purchase of logistics services including services of customs brokers, studding, transportation, storage and other additional services that service providers have in the territory of the warehouse), cargo insurance, removal and disposal of waste, certification, etc. Production department: works on installation and maintenance of equipment; cleaning of premises and territories; operation and rental of cars and special vehicles; training services (occupational health); information materials and equipment; removal and disposal of waste, etc.

For non-standard goods and services include goods and services competitive selection of suppliers, which could not be conducted due to the limitations of such proposals on the market of goods and services or be conducted in a free format taking into account specificity goods and services.

Placement of purchase order, confirmation of receipt of goods, performing works and rendering services; payment authorization is performed by workers of different departments, or different of the same department where it is possible to ensure segregation of duties in the implementation process of the supply.
The purchasing process begins with the fact that the initiator - an employee of the initiating department is authorized to create an application for the purchase of electronic systems ARRTU (electronic system of planning and accounting of spare parts and consumables to the main production and ancillary equipment) or ORACLE (electronic accounting system and planning resources (ERP)).

Purchasing is a complex, multistage process, the general scheme of which is presented in Appendix B.

In accordance with the policy operating at the plant in Vsevolozhsk, in order to obtain the best conditions of purchase of goods/services, the responsible employee of the purchasing group/authorized buyer, are required to use the advantages of a competitive market environment with the aim of selecting the most preferred supplier on a competitive basis.

Depending on the amount of purchases and comparison criteria offers the choice of a supplier can be carried out by different methods according to the table 7.

Purchasing Manager prepares a list of approved suppliers of raw materials on the basis of Sheet approved raw material, obtained from the product development department, and information from the managers of the purchasing department of the head office.

The suppliers of raw materials can be attributed not only manufacturers, but also official dealers, subsidiaries, sales offices, supplying the materials used in the main production process of the company. Information on suppliers of raw materials comes from the head office of the company.

The list is updated at least once a year. This list is confidential and stored in a limited access.

Implementation of the policy on procurement occurred at the end of last year. But the monitoring of the implementation of the policy on procurement began only this year alone. But we can speak about the positive impact of the use of policies, in particular focusing on the comparative analysis of the number of purchasers and the savings.

However, the price of products or services is considered as an important criteria for choosing a supplier, other different criteria play a critical part [35]. For example, purchased products with low quality may increase the deficiency rate and eventually lead to customer dissatisfaction; delay leads to the laying-off of production or increase the cost, which is caused by keeping more buffer stock. As a result, it is necessary to evaluate suppliers with a comprehensive framework of various criteria.
Table 7 - Supplier selection methods

<table>
<thead>
<tr>
<th>The total value of purchases (in rubles without VAT)</th>
<th>Criteria</th>
<th>Methods of supplier selection on a competitive basis</th>
<th>The authority deciding on the approval of the TOR, the definition of criteria and the choice of supplier</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 300 000</td>
<td>Price</td>
<td>Selection on a competitive basis, not obligatory</td>
<td>Manager of group</td>
<td>As a document for approval stands Purchase Order (PO).</td>
</tr>
<tr>
<td>300 000 – 1 000 000</td>
<td>Price / value (terms of payment)</td>
<td>Price comparison or Electronic trading</td>
<td>Manager of group</td>
<td>Supplier selection based on a comparison of three or more proposals on the criteria price / value</td>
</tr>
<tr>
<td>1 000 000 – 1 999 999</td>
<td>Price / value (terms of payment)</td>
<td>Price comparison or Electronic trading</td>
<td>Manager of group</td>
<td>Supplier selection based on a comparison of five or more proposals on the criteria price / value</td>
</tr>
<tr>
<td>2 000 000 – 2 999 999</td>
<td>Price / value (terms of payment)</td>
<td>Price comparison or Electronic trading</td>
<td>Manager of department</td>
<td>Supplier selection based on a comparison of five or more proposals on the criteria price / value</td>
</tr>
<tr>
<td>1 000 000 – 2 999 999</td>
<td>Multiple</td>
<td>Price comparison</td>
<td>Manager of department</td>
<td>Supplier selection based on a comparison of five or more proposals based on multiple criteria in filling Tender forms instead of price comparison</td>
</tr>
<tr>
<td>Over 3 000 000</td>
<td>Multiple</td>
<td>Tender procedure</td>
<td>TenderCommittee</td>
<td>Supplier selection based on a comparison of five or more proposals based on multiple criteria</td>
</tr>
</tbody>
</table>

And also after conclusion of the contract it is necessary to control and monitor him, at an early stage to identify and assess potential risks.
2. RISK MANAGEMENT

Organizations of all types and sizes face internal and external factors and influences, because of which it becomes impossible to determine how and when they will reach their goals. The impact of uncertainty on objectives of the organization is defined as «risk».

The concept of «influence» is considered as a deviation from the expected – positive or negative consequences, and goals can have different aspects (such as financial; aspects relating to occupational health and safety; environmental objects) and can apply to different levels (such as strategic level, organizational, project, product and process). Risk is often characterized by the ratio to potential events and consequences or a combination of these items. Risk is often expressed in a combination of the consequences of events (including the change in circumstances) and the associated likelihood of incidents. And uncertainty is the state, also partially, the lack of information regarding the understanding or knowledge of an event, its consequence, or probability.

The goal of risk management is to create a reference framework that will allow companies to handle risk and uncertainty [17]. Although risk management has been described as «one of the most of the most important innovations of the 20th century» by Steinherr [42].

Due to the instability and unpredictability of the current economic situation one of the most important tasks of supply chain management is the assessment and management of risks arising in the supply chain [15]. Risk management is a key aspect in supply chain management, especially in an unstable economic market, in which companies faced by with uncertainty of suppliers the sustainability, variable costs of the product, and even dangerous weather phenomena and natural disasters.

The Association for Operations Management (APICS) conducted a survey to examine practices, procedures, and plans in risk management across the supply chain in order to keep supply chain and operations management professionals informed of the challenges, innovations, and experiences of their peers[58].

According to this survey:

1) Supply chains still do not fully share supply chain risk plans. Only about half of organizations ask for risk management plans from their suppliers. But only a quarter of organizations ask for risk data from their distribution and logistics partners and third-party service providers.

2) Less than one in five respondents reported that their suppliers ask for their organizations’ supply chain risk plans. The cause of this may be related to supply chain risk visibility. This is an area that can improve without tremendous effort.
3) Almost 44 percent of respondents reported that they do not profile or consider risk and reward for partners. Approximately one in five reported that they informally profile risk and reward for each partner. The 2012 APICS Supply Chain Risk Folio looks at this topic. Integrating risk management into other areas of supply chain practice is developing at many organizations, with room for greater advancement. Supply chain risk management can be an ally to implementing other best practices such as supply chain strategy or sustainability.

4) One-third of organizations have contingency plans in place for key suppliers. About one in five organizations are developing plans, but almost one in five do not have plans. Only five percent of organizations have risk mitigation plans in place for all their suppliers.

5) To the question: In which meetings or events do you discuss supply chain risk management issues? Sales and operations planning (S&OP) meetings had the largest response at nearly 44 percent. Production planning meetings saw 39 percent. Less than 30 percent of respondents reported demand planning and 36 percent said new product development meetings. Years ago, these results probably would have been much smaller. Advanced supply chain risk planning remains an area for further development.

6) On the matter: Does your organization create time-to-recovery estimates for typical supply chain risk disruption events such as losing a key supplier or warehouse? About 60 percent of organizations reported “no” or “not very often.” One in four percent reported “yes—periodically.” (The Association for Operations Management, 2012)

Thus it can be argued knowledge of the risks and therefore their assessment is important information and development of this knowledge in the near future will only grow.

Risk management includes risk assessment (risk identification, risk analysis and comparative risk assessment) and risk treatment (adoption of rule to respond to the risk) [22].

2.1. The concept of risk and risk classification

The terms «risk», «uncertainty» «disruption» and «disaster» are frequently and interchangeably used in supply chains to describe the perceptions and interpretations of individuals and organizations. A general interpretation of risk is influenced by the negative consequences of variation in expected outcomes, their impact and likelihoods. Risk events are also studied with core supply chain activities and investigated with common business practices. Christopher and Peck relate the risks with the vulnerability and likelihood of being lost or damaged [59]. Interruptions to the flow of information, material and finance from the original supplier to
the end user which cause a mismatch between demand and supply are also
considered as risks.

In line with the definitions discussed above and to relate the risks with supply chain functional aspects we categorize the orientation of risk definitions related to operational characteristics, market characteristics, business/strategic characteristics, product characteristics and others. Table 8 shows the risk characteristics and features in each of the categories [42].

Table 8 – Risk definition criterion and description

<table>
<thead>
<tr>
<th>Risk definition criterion</th>
<th>Definition description/Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related to operational characteristics</td>
<td>Operational features of supply chain which mismatch demand and supply or even disrupt the functioning of supply chain and interrupt the flow of material, product and information.</td>
</tr>
<tr>
<td>Related to market characteristics</td>
<td>Market fluctuations which cannot be predicted precisely and change their nature, impact and occurrence over time.</td>
</tr>
<tr>
<td>Related to business/strategic characteristics</td>
<td>Specific characteristics of business, sector, their strategies and environment which cause an undesired event to happen and negatively affect the supply chain performance.</td>
</tr>
<tr>
<td>Related to product characteristics</td>
<td>Features related to the specific nature of products which make the supply chain vulnerable to risk and uncertainties.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Various other characteristics can also be considered which may fit in the above mentioned category or can be studied separately.</td>
</tr>
</tbody>
</table>

The APICS Dictionary, 13th edition, defines supply chain risk as «Decisions and activities that have outcomes that could negatively affect information or goods within a supply chain» [58].

Formally, risk in general can be defined as a collection of pairs of likelihood (L) and outcomes (or impact) (O):

\[
\text{Risk} = \{(L_1, O_1), (L_2, O_2), \ldots, (L_n, O_n)\},
\]

where On and Ln denote outcome n and its related likelihood. The distribution pattern of the (likelihood; outcome) pairs is called a risk profile. Definitions of risk must also have a time dimension or a specific time horizon (day, month, year, etc.) and a specific perspective or view that defines the unit of analysis (boundaries, what’s not included, etc.) [33].

How does this apply to the supply chain? Recently, several publications have advanced the conceptual clarity of the terms used in the domain of supply chain risk management—yet, there is still no commonly agreed nomenclature. According to [69] it is possible to distinguish four interrelated terms:

- Supply chain risk: it is defined as the negative deviation from the expected value of a certain performance measure, resulting in negative
consequences for the focal firm. Hence, risk is equated with the detriment of a supply chain disruption. The authors explicitly adopt the notion of risk as purely negative as the one that corresponds best to supply chain business reality. As a consequence, they do not consider either «happy disasters» or the situation where managers intentionally «gamble» on risk.

- Supply chain disruption: a supply chain disruption is an unintended, untoward situation, which leads to supply chain risk. For the affected firms, it is an exceptional and anomalous situation in comparison to every-day business. Supply chain disruptions can materialize from various areas internal and external to a supply chain. Consequently, their nature can be highly divergent;

- Supply chain risk source: attempting to circumscribe supply chain disruptions (i.e. the demarcation of supply chain risks from other business risk), many scholars have proposed classifications in the form of typologies and/or taxonomies of risks. The derived classes of supply chain disruptions are often labeled supply chain risk sources.

- Supply chain vulnerability: while a supply chain disruption is the situation that leads to the occurrence of risk, it is not the sole determinant of the final result. It seems consequential that also the susceptibility of the supply chain to the harm of this situation is of significant relevance. This leads to the concept of supply chain vulnerability. In other way, Christopher and Peck (2004) define supply chain vulnerability as «an exposure to serious disturbance arising from risks within the supply chain as well as risks external to the supply chain» [31], while Barnes and Oloruntoba (2005) describe vulnerability as «a susceptibility or predisposition to loss because of existing organizational or functional practices or conditions» [11].

In order to better understand and define risk in the supply chain the different perspectives need to be understood. Figure 7 shows the three perspectives in a supply chain and list some of the risk definitions related to them [33].

Supplier Facing looks at the network of suppliers, their markets and their relationship with the «company». Customer Facing looks at the network of customers and intermediaries, their markets and their relationships with the «company». Internal facing looks at the company, their network of assets, processes, products, systems and people as well as the company’s markets. In all cases, a global perspective is essential [11].

The main risks factors can identified as follows:

Financial risk is a kind of risk which indicates that the organization has no enough money to face to its financial consequences.
Strategic risk means the profit at the present and in the future of organization. This kind of risk is subject to companies’ strategic targets. When the business strategies advance and fix resources are against them, strategic risk will appear.

Operational risk. Nowadays, organizations are trying to upgrade the techniques for measurement, monitoring and decreasing of operational risks. For example: the results getting from unsuccessful processes or a few equipment, inefficient employees and systems in external accidents, damages are brought about from processes, improper personnel and defective systems or accidents due to the companies outside factors are those to be mentioned.

There are two kinds of human resources risks: 1-The absence of trained persons in order to apply management programs. 2-The important necessary strategy section to connect with risks is the intelligence of those who have to deal with unexpected accidents.

Technological risk. Informational systems and organizational activities, automation, projects rebate, misunderstanding of shareholder's role and technology's position are parts of technological risks. These risks should be recognized earlier, and a set of activities to avoid the serious problems proceeding from them be considered later on.
Fame risk has been described as a current or future risk for earning and increasing capital from different viewpoints of financial firms and commercial beneficiaries. The duty of all employees is to keep organization fame.

Laws risk. At any environment which is changeable, these controlling laws can give confidence regarding the fact that identification, management and control of any kind of controlling risks, now and in the future will be done. Control teams on laws are including controlling experiences and especial risks management. Not only they know laws, but have also trained for contrasting, executing and accessing to risks [67].

Relationship risk differs in that it involves both the vendor and the contracting company. The name itself offers a definition: Relationship risk is concerned with a third party’s risk profile in relation to the company that has hired the vendor. This includes scope of services, contract protections, geographic location of services, and delivery—things that the third party does that directly affect the first party. Relationship risk is also called inherent risk: the risk that is inherent simply by engaging in business with a third party. Any relationship with a vendor is inherently risky—a supplier, for example, may not deliver its goods per the contract terms, thus leaving your company without the (potentially important) product. Assessing relationship risk is essential in managing your vendors, especially the ones that are key to company’s successful operation [25].

Risks arise in all socio-economic activities but in different forms depending on the type, mode of expression and size. After analyzing the case studies (real implementations, best practices, lesson learned) and reviewing the literature in the field, risks are presented in table 9 [32].

**2.2. Risk assessment**

In today’s regulatory and complex supply chain environment, no decision includes the risks related to the environment. In fact, risk management should be a major deliverable for any supply chain team. Additionally assessing is a way of determining how to link together the different types of data that can be identified in the supply chain [27].

Risk assessment is a major component in risk management, which formal processes is identification, analysis and risk assessment. Risk assessment is performed to estimate the quantitative damage that can be expected to result from hazards and their impacts on organization. When it is impossible to conduct a quantitative estimation, risks are ranked by qualitative assessment.
<table>
<thead>
<tr>
<th>Risk Source</th>
<th>Classification</th>
<th>Examples from SCM implementation projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human factor</td>
<td>- human behavior risks; - human psychological factors risks; - risks from individual activities; - risks from user involvement and training</td>
<td>- human behavior risks; - human psychological factors risks; - risks from individual activities; - risks from user involvement and training.</td>
</tr>
<tr>
<td>Organization</td>
<td>- strategic: risks related to the organization’s strategy; - operational: risks affecting the current activities of the company; - financial: risks related to the financial aspects of the company; - hazard: unpredictable events (usually caused by nature).</td>
<td>- risks related to the intellectual capital of the company, changes taking place at the macroeconomic level; - fraud, insufficient resources, business process reengineering failures; - lack of liquidity, failure in paying the contractual obligations by the business partners; - foreign exchange risk - natural disasters, fires.</td>
</tr>
<tr>
<td>Leadership style</td>
<td>- risks arising from the differences in management policies; - risks arising from the management activities and controls; - risk arising from organization management skills, poor management.</td>
<td>- lack of executive support; - changes in requirements, poor leadership; - failure to attract qualified staff, insufficient knowledge.</td>
</tr>
<tr>
<td>External Environment</td>
<td>- risks arising from economic, social, political and environmental circumstances</td>
<td>- changing market conditions, harmful competition actions, outdated software; - terrorism, state of war.</td>
</tr>
<tr>
<td>IT&amp;C Resources of the Organization</td>
<td>- risks arising from technical and technological problems; - risks arising from the software design and implementation; - risks arising from the administration of information.</td>
<td>- inadequate documentation, applications are implemented without meeting the initial requirements, inadequate know how; - instability of the current technology, inability to connect to the legacy systems; - misunderstanding the change requirements, systems are not integrated.</td>
</tr>
<tr>
<td>Relationship with third parties</td>
<td>- risks arising from legal and contractual relations; - partnerships with SMEs - risks arising from reputation damage.</td>
<td>- inadequate performance of third parties, inadequate protection of intellectual property tensions between clients and contractors; - increased confidence in providers; - breaches or non-compliance with the law.</td>
</tr>
</tbody>
</table>
2.2.1. Risk identification

Risk identification is the operation by which an organization systematically and continuously identifies property, liability, and personnel exposures as soon as or before they emerge [26].

Risk identification is the first step of risk assessment. At this stage, identify the source of the risk, its impact, risk cases (including changes in circumstances), their causes and their potential consequences [52].

The purpose of this step is to make a comprehensive list of risks based on those risk cases, which may set the stage for, to increase the opportunity to prevent, degrade, reduce the achievement. It is important to identify the risks associated with lost opportunity. Comprehensive identification is critical, because a risk that is not identified at this stage will not be included in further analysis.

Identification should include all risks (whether the source is under control of the organization or not), even if the source of risk or its cause is not evident. Risk identification should include checking chain reaction, certain consequences, including cascading effects and cumulative effects. She also needs to consider a wide range of impacts, even if the source of risk or the cause is unclear. In addition to identifying the possible consequences it is necessary to consider possible causes and scenarios that may indicate presumable consequences. All significant causes should be taken into account. Identifying risks in supply chain can be challenging because a risk incident can have a different impact on the different entities in the supply chain [52].

For identifying risks can be applied the following methods: questionnaire, brainstorming, semi-structured interviews, check lists, Delphi etc. After all implementation of risk identification need to develop list which will incorporating all the risks that could occur.

2.2.2. Risk analysis

The risk analysis includes the analysis and study of information about risk. The risk analysis provides an input to the overall risk assessment process, helps in making decisions regarding the need for risk treatment, and also helps to choose appropriate strategies and methods of risk treatment.

Risk analysis involves analyzing the likelihood and consequences of identified hazardous events based on the availability and the effectiveness of control methods. Data about the likelihood of events and their consequences are used to determine the level of risk. The risk analysis includes the analysis of the sources of hazardous events, their positive and negative consequences and probabilities of occurrence of these events. It should be identified the factors influencing the probability of an event and
its consequences. An event can have multiple consequences and can affect different targets.

Risk analysis usually includes an assessment of the range of possible consequences of an event, situation or circumstances and their corresponding probabilities to determine the level of risk. However, in some cases, for example when the consequences are insignificant, or the probability of an event is extremely low, for making decisions can be quite studies only one parameter.

In some cases, the consequence may be the result of multiple events or identified event. In this case the risk assessment should focus on the analysis of the significance and vulnerability of the components of the system. Thus it is necessary to define methods of handling risk, appropriate levels of protection and recovery strategy.

In the analysis of consequence determine the character and type of impacts that may occur in response to specific events, situations or circumstances. An event can have several consequences of different value, to affect the achievement of several goals and to affect the interests of the stakeholders of the parties involved in the organization. In other words parties involved in supply chain to creating value.

Consequence analysis can change from simple descriptions of the results to detailed quantitative modeling of the situation, processes and analysis of vulnerabilities. The impact can have a little consequences but a high probability of occurrence or the significant consequences and low probability of occurrence, as well as any intermediate option. In some cases, it is appropriate to focus on the dangerous events with very dangerous consequences, because these events cause the most concern. In other cases, it is important to analyze separately the consequences of high and low importance to the organization. For example, often repetitive, minor impact events can have large cumulative or long term effects. In addition, processing steps these situations the risk is often different, so it is useful to analyze separately.

Analysis of the consequences may include the following:

- taking into account of existing risk management techniques to reduce the consequences and all the related factors influencing the consequences;

- a study of the relationship of the consequences of hazardous events and stated objectives;

- separate study of long-term consequences of the event and what is happening in the present time, if they are included in the scope of the risk assessment;

- consideration of secondary impacts, such as the consequences of acting on a coherent system of activities, equipment or organization.
To assess the probability are usually used the following three general approaches that can be used independently or together:

1) Using the relevant historical data to identify events or situations that occurred in the past, and allow the possibility of increasing the probability of their occurrence in the future. The data used should refer to the system in question, equipment, organizations or activities as well as to the requirements of the organization. If, in accordance with the available data, the frequency of occurrence is very low, all estimates of probability will have a high uncertainty. This is typical for situations in which the probability of occurrence is close to zero, when the occurrence of an event, situation or circumstances in the future very unlikely.

2) Use to assess the probability of forecasting methods, such as analysis of fault tree analysis and the tree analysis error events. If historical data is unavailable or unreliable, it is possible to assess the probability of an analysis of the system, activities, equipment or organization and related failures or operational. In the application of forecasting methods, it is important to provide a complete analysis of the possibility of a common cause of failures, including failures of different parts or components of the system, caused by a single cause.

3) Using expert evaluation in a systematic and structured process of assessing the probability. For expert evaluations should use all available information, including historical data, information about the specifics of the system, the specifics of the organization, experimental data, etc. There are formalized methods of obtaining expert assessments that help to formulate appropriate questions. Available methods include the Delphi method, paired comparison, ranking by measurement categories and absolute ratings.

2.2.3. Comparative risk evaluation

Comparative risk assessment includes comparing the level of risk with risk criteria established when defining the scope of risk management, to determine the type of risk and its significance.

Comparative risk evaluation uses information about the risk obtained in the risk analysis. The results of the comparative risk evaluation used for decision making about future actions. Decisions may relate to such issues as:

- the activity importance for risk treatment;
- priorities for risk treatment;
- the need to implement the action;
- selection of strategy to risk treatment.

Based on the obtained data about the consequence and probability of risk, then it is necessary to analyze the level of risk. The risk level can be expressed in monetary units, but sometimes it is determined by expert
evaluation, depending on the method, which used to assess the probability of risk and its consequences.

If there are quantitative values of probability and consequences risk level can be found by the formula:

\[
\text{Risk level} = P \times C,
\]

where \( P \) – probability of occurrence; \( C \) – magnitude of consequences [60].

The combination of probability of occurrence and magnitude of consequences creates four basic categories of risk level, as shown in figure 8.

In what follows, determined level of risk is required for comparative risk analysis and decision-making to respond to risk.

Round 1 in figure 8 is a risk that has improbable-to-moderate probability with a tendency to moderate risk, and a potential for serious losses. The size of the round represents a quite large effect. Round 2, on the other side, represented a small effect with a risk that has no losses and is unlikely. Obviously, risk level may occupy a spectrum rather than fitting nearly into categories, but defined risk level categories such as these to help decide on a risk response.

Risk treatment is the complex activity aimed at modifying and/or mitigating risks and the potential economic and financial impact of such risks through risk control and risk financing actions [13]. There are four strategies for the treatment of risk:

- risk avoidance;
- risk acceptance;
- risk transfer;
- risk mitigate. Table 10 shows brief description about all of them.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid</td>
<td>Eliminate</td>
</tr>
<tr>
<td>Mitigate</td>
<td>Reduce the frequency of causes (prevention); eliminate some causes; reduce the frequency of consequences; reduce or mitigate consequences (mitigation)</td>
</tr>
<tr>
<td>Transfer</td>
<td>Transfer by contract; transfer by insurance; physical transfer; risk sharing</td>
</tr>
<tr>
<td>Accept</td>
<td>Retain</td>
</tr>
</tbody>
</table>

Risk avoidance option represents the decision not to undertake, when practicable, the activity that contains an intolerable risk. It means that management will choose an alternative that is either a different more tolerable approach to completing the required activity or different and less risky methodology or process within the activity.
The APICS Dictionary, 14th edition, defines risk acceptance as «a decision to take no action to deal with a risk or an inability to format a plan to deal with the risk» [7]. In addition to risk that cannot be dealt with through planning, risk acceptance is often the strategy for low probability, low magnitude risks or risks that have high costs of transfer or mitigation.

Risk transfer means that organization can move the resource or financial effects of a risk to a third-party such as an insurance company or a supplier. This requires purchase of insurance or bonding or contractually transferring risk to an outsourcing partner.

Risk mitigation means that organizations can apply preventive measures to reduce the probability and/or severity of identified risks. Proper design of facilities, and processes, employee training, and compliance management are all examples [60].

Risk transfer and risk mitigation can be implemented in one or both of the following types of risk response plans:

- A prevention action is any risk response that occurs before a harmful risk event occurs. The intent is to reduce the probability or severity of the risk (or eliminate the risk).
A contingent action is any risk response that occurs during a harmful risk event or after it has occurred. The intent to minimize the monetary, physical, or reputation damage from the risk event.

Risk aversion and loss aversion go hand in hand, and the question is whether managers will pay too little or too much attention to the low probabilities and high consequences associated with catastrophic events. When uncertainty is high, managers may underestimate the importance of an issue, and may – in the illusion of being in control – ignore or downplay the possibility of random or uncontrollable occurrences, and may downplay the probability of loss compared to the amount that is probable.

### 2.3. Risk assessment methods

The methods used in risk analysis can be qualitative, quantitative or mixed. The degree of depth and detail of the analysis depends on the specific situation, the availability of reliable data and the needs of the organization related to decision making.

Supply chain risk assessment is usually performed by means of a number of qualitative, semi-quantitative, and quantitative methods. Sinha, Whitman and Malzahn [34] assess the severity of risk consequence on a supply chain. To this end, they use three qualitative levels: high, medium and low. Wu, Blackhurst and Chidambaram [5] apply the Analytic Hierarchy Process (AHP) to calculate the relative weight of each risk factor, which is an indicator how important a risk factor is. Moreover, several models assess risky events by evaluating the probability of occurrence and the severity of consequence. Zsdisin[68] and Sheffi with Rice [50] use qualitative evaluations for these two dimensions. Hallikas, Virolainen and Tuominen[44] define semi-quantitative evaluations: values ranging from 1 to 4 for the probability of occurrence represents very unlikely, improbable, probable, and very probable events respectively, and values from 1 to 4 for the severity of consequence represents insignificant, minor, serious, and catastrophic consequences of risky events respectively. Finally, quantitative risk assessment usually relies on simulation methodologies and discrete event simulation[47, 66].

If a qualitative risk assessment to determine the consequences, probability and risk level on a scale of high, medium and low or as something else; assessment of consequences and probabilities can be combined; a comparative evaluation of the level of risk in this case is carried out in accordance with quality criteria. Qualitative risk assessment can assist a risk manager is priority setting, policy decision making, such as decisions to allocate resources to sampling of risk reduction action [14].

In mixed methods use a numerical scale evaluation of the impact, probability, and combinations thereof to determine the level of risk using
the appropriate formula. Scales can be linear, logarithmic or can be built on different principles. Used formulas, respectively, maybedifferent.

Quantitative analysis evaluates the practical importance and value of the consequences, their possibility and get the value of the level of risk in certain units. Full quantitative analysis may not always be possible or desirable due to lack of information about the analyzed system, the activities of the organization, the lack of data, human factor, etc. or because such analysis is not required, or work on the quantitative analysis are too large. In this case, the ranking of risks by highly qualified specialists can be more effective.

The literature review reveals that most of risk management approaches require a careful recording of past events and data. An accurate understanding of risk depends on huge amounts of historical data and rich experience of personnel. Therefore companies need to extra invest in information systems and human resources to adopt such risk management techniques.

International ISO standard «ISO/IEC 31010:2009 Risk management — Risk assessment techniques» 31 describes the basic methods of risk assessment that are applicable depending on the stage of the risk assessment process.
3. SUPPLY CHAIN SOURCING RISK MANAGEMENT METHODOLOGY

3.1. Identification of the composition of source risks in the supply chain

Risks of source can arise at strategic and operational levels of decision making in supply chain management, so when consider sourcing process it may arise strategic risks and during the purchasing process – operational risks. There are also risks independent of decision-making in the company. Using the technique of the SCOR model – decomposition, represent the category of risks. Table 11 presents the risks of source.

Table 11 - Decomposition of the risk source

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Catastrophic</td>
<td>Natural disaster</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Man-made accidents</td>
</tr>
<tr>
<td></td>
<td>Economic</td>
<td>Fuel price fluctuation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exchangerate fluctuation</td>
</tr>
<tr>
<td></td>
<td>Social</td>
<td>Labor industrial action</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shut down of transportation hubs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Computer virus</td>
</tr>
<tr>
<td></td>
<td>Legal</td>
<td>Changes in import/export regulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tariff changes</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>Market price of resource changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Production technological changes</td>
</tr>
<tr>
<td></td>
<td>Partner</td>
<td>Supplier business</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supplier product quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supplier capacity constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suppliers’ opportunistic behavior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supplier’s production sudden disruption</td>
</tr>
<tr>
<td>Internal</td>
<td>Strategic</td>
<td>Manage Sourcing Business Rules (sES.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assess Supplier Performance (sES.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintain Source Data (sES.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manage Incoming Product (sES.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manage Supplier Network (sES.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manage Import/Export Requirements (sES.8)</td>
</tr>
<tr>
<td></td>
<td>Operational</td>
<td>Schedule Product Deliveries (sS1.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Receive Product (sS1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verify Product (sS1.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transfer Product (sS1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Authorize Supplier Payment (sS1.5)</td>
</tr>
</tbody>
</table>

On the first level present as external risks – independent decision-making in the company and internal – dependent decision making in the company. On the second level, external risks are broken down depending on
the impact factor; the internal depends on decision making level. At the third level in the table presents the names of risk’s groups, disclosing risks of second level. The names of the internal groups of risks at this level are given accordingly to the names of the source sub-processes of the SCOR model.

When identifying risks, it were conducted semi-structured interviews with employees on direct and indirect purchasing in the course of which was determined as part of the hazardous events in the procurement process. Also throughout the process of risk identification was used a preliminary hazards analysis. So described sub-processes of source, represented in SCOR are compared with source processes of company. On the basis of the SCOR metrics were formulated risks of source. Further, all potential risks have been reviewed by the purchasing manager and approved.

Catastrophic risks are connected with some dangerous events which may occur by natural disaster, such as storm during transportation of materials, tsunami, or man-made incident, for example labor shortage, vandalism, theft, even terrorism and etc. [65]. The probability of a catastrophic event occurring is very low, while at the same time the estimates of the probability of the occurrence for such rare events are inherently ambiguous. Some external risks have been described in previous part.

3.1.1. Strategic risks

Strategic risks are presented on the third level related to Enable source process of SCOR model. Table 12 reflects the risks related to this category of risk.

In determining these risks were considered stages of the company processes sourcing. The risks associated with the sub-process Manage Sourcing Business Rules, were classified as stages: identification of needs the initiator of the procurement; and then broadcast the requirement to the procurement specialist; the choice of method of procurement; supporting documentation; invitation, clarification and closure proposals; evaluation of proposals; selection of the winner. The sub-process Manage Incoming Product will take the stage of development of a specification. Manage Supplier Network is characterized by risks related to the negotiation stage.
<table>
<thead>
<tr>
<th>Sub-processes of Enable Source</th>
<th>Third level strategic risks</th>
</tr>
</thead>
</table>
| **Manage Sourcing Business Rules (sES.1)** | - The risk of inconsistency between the supplier and the level of cooperation established on the basis of goals, objectives, strategies of the company;  
- The risk of misunderstanding the needs by initiator of order;  
- Overestimation of the needs by initiator;  
- Misinterpreting the needs of the initiator by the buyer;  
- Insufficient of funding;  
- Deadlines (hard-to-achieve deadlines);  
- The failure to identify a potential source of resources;  
- Select the unacceptable method of purchasing;  
- The terms and conditions of the tender not acceptable for participants;  
- Message insufficient information in the invitation to participate in competition;  
- Insufficient replies to requests from bidders;  
- Violation of confidentiality;  
- Insufficient number of replies;  
- Lack of replies from the supplier with the known quality of goods/services;  
- Failure of effective assessment procedures;  
- Breach of security;  
- Mismatch of commercial proposals requirements;  
- The inability to identify a clear winner;  
- Inappropriate choice of the supplier;  
- Selecting the incorrect product; |
| **AssessSupplierPerformance (sES.2)** | - The risk of not invite to participate in the tender of all possible suppliers;  
- The risk not to inform about tender of a key supplier;  
- The risk of not finding a sufficient number of participants; |
| **MaintainSourceData (sES.3)** | - Inability to obtain full information about the supplier |
| **Manage Incoming Product (sES.6:)** | - Incomplete specification or specific commercial specification about supplier (use of brand name);  
- Wrong definition of the product or service in the specification;  
- Biased specifications;  
- Insufficient number of amount of requirements |
| **Manage Supplier Network (sES.7:)** | - Mismatch of expectations of the buyer and the supplier;  
- Insoluble question of the point of the agreement;  
- The inability to secure the required conditions |
### 3.1.2. Operational risks

Operating risks include the Source Stocked product (sS1) sub-processes and Source MTO product (sS2). Because sub-processes describing these two processes in SCOR model are the same, consider the risks specific to them together. These sub-processes describing in table 6.

The risk of not getting the material due to the change in supplier’s lead time is typical for sub-process Schedule Product Deliveries. When consider the process Receive Product the potential risks are to receive a partial amount of the ordered material; incorrect shipping documents; obtain a product in the wrong packaging.

Verification of the obtained raw material is one of the key sub-processes that ensure compliance with quality and checking that raw materials does not change the properties of the finished product. At this stage the possible risks: get the raw materials with inadequate quality (non-conforming specifications) and receive materials with non-correct content.

Delivery materials in-time is an important component of supply chain reliability. For company delivered raw materials in time is considered, if delivered in time of Freight Terms supplier, and the delivery in this range for each vendor shall be not less than 80%. Table 13 presents Delivery performance targets. Risk of a delay in delivery occurs when the deviation from the expect date of delivery.

<table>
<thead>
<tr>
<th>FreightTerms</th>
<th>Not before (-) / no later (+) days</th>
</tr>
</thead>
<tbody>
<tr>
<td>for terms DDP (filling)</td>
<td>(-0/+0)</td>
</tr>
<tr>
<td>for terms DDP (car)</td>
<td>(-5/+1)</td>
</tr>
<tr>
<td>for terms DDP (r/w)</td>
<td>(-5/+2)</td>
</tr>
<tr>
<td>for terms FOB</td>
<td>(-0/+0)</td>
</tr>
<tr>
<td>for terms FCA/EXW</td>
<td>(-0/+0)</td>
</tr>
<tr>
<td>for terms CIF</td>
<td>(-5/+1)</td>
</tr>
<tr>
<td>for terms DAP</td>
<td>(-5/+1)</td>
</tr>
</tbody>
</table>

Delay payment of the invoice is an undesirable event in the business. The provider may decide that the company is not solvent, and this may negatively affect the company's reputation. And since the company in order to prevent fraud order goods, shipment of goods and the transfer of payment is carried out by different persons, so in sub-process Authorize Supplier Payment possible fail.
3.2. Sourcing risk assessment in the N supply chain

The effects of external risks range from short working process interruptions to major natural disasters that occur with some frequency and then rarer these risks manifest then the more difficult to quantify them. In this connection, they require the use of qualitative assessment methods, in particular expert opinions.

The consequences and the probability of internal strategic risk may also be assessed using only qualitative methods. The following are the possible consequences for some of identified risk, presented.

The mismatch between the supplier and the level of cooperation established by the company (on the basis of goals, objectives, strategies) can have a negative impact on the company’s business reputation.

The risk of misunderstanding the needs by initiator of the order will result in the purchase of unsuitable products or services, loss of funds, order is failed. Overestimation of the needs by initiator can increase cost and lead to low competition among suppliers.

Misinterpreting the needs of the initiator by the buyer may result in totally unacceptable purchase or most appropriate product or service; loss of time; an increase the purchase costs.

Selection the unacceptable method of purchasing will lead to a need to re-selection; possible changes in value; failure to obtain appropriate commercial proposals covering a set price.

Insufficient number of replies will lead to re-tendering; increases in costs; delay sending client; poor value for money due to limited competition.

Failure of effective assessment will lead to inconsistent estimation; possible complaints from bidders, a subjective, not an objective evaluation of proposals. The inability to identify a clear winner may result in complaints from the participants.

Inappropriate choice of the supplier can lead to the fact that the supplier be unable to comply fully with the terms of the contract. Selecting the incorrect product will lead to inability to meet customer needs.

3.2.1. Assessment of operational risks

Key Performance Indicators of SCOR model on the third level is applicable to the assessment of the probability of operational risks. The consequences from the existence of operating risks may be different, the worst of which them stop production. Based on the indicators of the third level of the SCOR model, we will present formulas for calculating the probability of occurrence.
For calculating the probability of a risk not to receive the material due to changes lead time of supplier – $P_{lt}$ will use the reliability measure Schedules Changed within Supplier's Lead Time (RL.3.27):

$$P_{lt} = 1 - RL.\,3.27 = 1 - \frac{n_{lt}}{N}, \quad (2)$$

where $n_{lt}$ – the number of deliveries with changed schedules lead time supplier; N – the total number of deliveries, performed according to the measured period.

Calculating the probability of getting incomplete volume of the ordered material $P_{pc}$, we use the indicator of Orders/ Lines Processed Complete (RL.3.18):

$$P_{pc} = 1 - RL.\,3.18 = 1 - \frac{n_{pc}}{N}, \quad (3)$$

where $n_{pc}$ – the number of deliveries, with the right amount of material delivered; N – the total number of deliveries, performed according to the measured period.

The probability getting the material with irregular shipping documents $P_{sd}$ take the indicator Orders/ Lines Received with Correct Shipping Documents (RL.3.23) to calculate:

$$P_{sd} = 1 - RL.\,3.23 = 1 - \frac{n_{sd}}{N}, \quad (4)$$

where $n_{sd}$ – the number of deliveries, with the correct shipping documents; N – the total number of deliveries, performed according to the measured period.

The probability of getting the material with incorrect packaging with incorrect quantity $P_{cp}$, using the indicator Orders/ lines received with correct packaging (RL.3.22), is equal to:

$$P_{cp} = 1 - RL.\,3.22 = 1 - \frac{n_{cp}}{N}, \quad (5)$$

where $n_{cp}$ – the number of deliveries, in which the material was right packaging and the right amount; N – the total number of deliveries, performed according to the measured period.

The probability of getting defect material $P_{df}$ define using the indicator Orders/ Lines Received Defect Free (RL.3.19):

$$P_{df} = 1 - RL.\,3.19 = 1 - \frac{n_{df}}{N}, \quad (6)$$
where $n_{df}$ – the number of deliveries, in which the material was free of defects; $N$ – the total number of deliveries, performed according to the measured period.

To measure the probability of risk of material other content $P_{cc}$ will use the indicator Orders/ lines received with correct content (RL.3.21):

$$P_{cc} = 1 - RL.3.21 = 1 - \frac{n_{cc}}{N},$$  

(7)

where $n_{cc}$ – the number of deliveries with correct content of materials; $N$ – the total number of deliveries, performed according to the measured period.

The probability of getting material not on-time $P_{tot}$, using the indicator of Product Transferred On-Time (RL.3.25), we calculate by the formula:

$$P_{tot} = 1 - RL.3.25 = 1 - \frac{n_{tot}}{N},$$  

(8)

where $n_{tot}$ – the number of deliveries, which was delivered on-time; $N$ – the total number of deliveries, performed according to the measured period.

Now according to available data will conduct the calculation of the probability of occurrence of the risk to get material not on time. To simplify the data processing combine suppliers depending on the class material. According to table 3, we generate the group of materials the chemicals, which will include suppliers of activators, crosslinking agents, retarders/accelerators, antioxidants, paints, anti-tack agents, fillers, resins. And suppliers for other materials will leave without changes.

To calculate the probability of the risk we use of the available consolidated report of 2014 purchasing out ERP system Oracle (Appendix C). Using the formula (8), count one of the indicators of reliability of the third level of SCOR model and the probability of obtaining the material is not in time.

Table 14 shows the indicators are Product Transferred On-Time to Demand Requirement for each group of raw material suppliers.

3.3. Treatment strategies

Prior to deciding on an appropriate response for each identified risk, the organization must balance the cost of the risk response against the risk level. That is, the cost of a preventive action and/or contingent action must be balanced against the benefits the action provides in terms of reduced costs from a risk event occurrence and/or reduced the probability of occurrence. This allows the organization to achieve a best cost outcome for
Table 14 - Indicator RL.3.25 and the possibility of delivery is not on time by the raw materialssuppliers of the various groups

<table>
<thead>
<tr>
<th>Group of suppliers</th>
<th>RL.3.25, %</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon black</td>
<td>43</td>
<td>0,57</td>
</tr>
<tr>
<td>Chemicals</td>
<td>46</td>
<td>0,54</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>74</td>
<td>0,26</td>
</tr>
<tr>
<td>Polymers</td>
<td>35</td>
<td>0,65</td>
</tr>
<tr>
<td>Accessories</td>
<td>67</td>
<td>0,33</td>
</tr>
<tr>
<td>Steel cords &amp; beadwires</td>
<td>64</td>
<td>0,36</td>
</tr>
<tr>
<td>Tyre Cord Fabrics</td>
<td>78</td>
<td>0,22</td>
</tr>
</tbody>
</table>

each supply chain vulnerability. The best-cost outcome is one that addresses all of the highest priority risks first and in which the response is never more expensive than the risk itself would cost.

For deciding to which strategy use we need to provide best cost analysis. A best-cost analysis of risk can be performed by multiplying the anticipated cost of the business disruption by the probability of its occurrence:

Best-Cost Analysis of risk = AC×P, \hspace{1cm} (9)

where AC – anticipated cost of occurrence, P – probability of occurrence.

The resulting amount can be used as a spending target or limit for risk mitigation or prevention efforts.

For example, if the cost of occurrence from accepting a risk less than cost required on it's elimination removal, in this case, it is necessary to accept it. Otherwise, take one of the strategies: transfer or reduce.

If the probability and/or consequence determined by the qualitative methods. So if the consequence and probability is defined as low, in this case, the risk needs to be accepted. The magnitude of consequences and probability of large risks must reduce or must constantly monitor. Strategy transfer applies in the case of low probability but high consequences. If both options of risk are very high risk, you need to apply the strategy avoid.

For external risks we can apply some mitigation actions. For example price increased by suppliers can be blunted in several ways: by signing long-term contracts, having redundant suppliers or, in rare instances, holding inventory.

The exchange-rate risk, which influence on price of raw materials in company countered by creating in contract corridors for price depends on the exchange rate.
4. TECHNO-ECONOMIC JUSTIFICATION

The implementation of risk management in the company will reduce the amount of risk in the supply when the relationship with suppliers and increase the company's competitiveness. Because there are different risk management strategies for responding to risk, which depends on the level of risk, its probability and impact, the effect will be different for each of them.

Since it was not possible to quantify all the risks, to calculate the effectiveness of the implementation of the methodology as a whole will not succeed. Let's try an example has already identified risk to calculate the effect and then the expected economic efficiency from the use of the sourcing risk management methodology.

Consider calculation the economic efficiency from implementation of the sourcing risk management methodology for the risk of delivery of raw materials is not at a set time.

According to the expert, in the event occurrence risk of delivery not on time will entail different costs. Namely, early delivery is less critical than the delay of delivery. In case of early delivery the company have to adjust the payments to the supplier (need to pay earlier than planned), as well as take their warehouse space (unplanned growth stocks). In the case of deliveries to the external warehouse 3PL, have additional costs for storage. Therefore, the company specifically for the occasion, use strategies to mitigate, through working with suppliers to improve the level of service (accuracy of deliveries) and through the increase of the allowable deviation from the desired of the date delivery by a larger amount than the delay.

The late delivery is of the most criticality, because it can have a severe impact on business (plant’ downtime, failure to comply with order) - tens of thousands of dollars per hour. So here company have to apply risk avoidance through the safety stock, as well as mitigation through the same work as in the case of early delivery - improving the level of service providers, etc.

Also, the expert noted that «the strategy of «avoidance» is probably the most expensive and the most reliable of all 4 strategies. It used to control the delays of delivery through the creation of insurance reserves; freezes working capital for tens of millions Euro. If company chooses risk «acceptance»as the cheapest strategy, sooner or later, the risk will fall into another category (most likely to mitigate). «Transfer» is used to transfer the risk of loss of damage to the load provider (DAP, CIF) denominated or to the carrier (FCA, EXW). This strategy does not encompass the risk of stopping our production. Insurance is somehow taken into account by the contractors, which means we are paying the price of the product or service
costs. Risk «mitigation» is the most fashionable method. There are many options, ranging from the development and use of alternative suppliers, carriers, improvement of accounting systems, planning. It costs something between «avoidance» and «acceptance».

Efficiency (economic and social) is the ratio of economic or social effect to the cost of his achievement. Schematically, this can be expressed as follows:

\[ EE = \frac{E}{C} \]  

(10)

where EE - economic efficiency; E - the effect (result); C - costs of receive it or the resources used.

The economic impact, in turn, is determined by the following formula:

\[ E = R - C, \]  

(11)

where R – the intended result of the implementation of risk; C - costs when taking risk or resources used when choosing one of the strategies for responding to risk.

To calculate the effect of using supply chain sourcing risk management methodology is required to give conditional characteristic for each parameter. In this particular case, the cost will consist of costs to develop and conduct risk assessment and the contribution that you must perform on the findings of the comparative risk evaluation. As the costs of conducting risk assessments is the time of the employee conducting the risk assessment. So here the key indicator will be the costs of labor (CoL), which is calculated by the formula:

\[ CoL = W \times N \times 12, \]  

(12)

where W - the average monthly wage of 1 employee, rubles; N - number of employees.

The result is expressed in terms of the level of risk (LoR). The level of risk is given by:

\[ \text{Risk level} = P \times \text{MoC}, \]  

(13)

where P – probability of occurrence; MoC – magnitude of consequences [60].

The probability of this risk, we will find by the following formula:
\[ P = \sum \frac{p_i \times n_i}{n_i}, \quad (14) \]

where \( p_i \) – the probability of occurrence of risk to the \( i \)-th supplier; \( n_i \) – the number of deliveries committed by the \( i \)-th supplier for the calculated period.

The magnitude of consequences in case of later delivery will find through costs to production downtime, which will lead to the failure to comply with orders, is the worst case consequences that may result in this danger. And in case of early delivery magnitude of consequence will calculate as the theoretical loss on early payment, it can estimate by \% of credit (or by the key interest rate of the Central Bank) and the number of days of early payment and the share of raw materials in the average annual turnover.

4.1 Effectiveness calculation of using methodology in case getting material not on time

Result. The probability of the risk we will find by formula (14). The table 15 presents the data for calculation; they were calculated according to the available statistical information for the year 2014.

<table>
<thead>
<tr>
<th>Group of suppliers</th>
<th>Total number of delivery</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon black</td>
<td>694</td>
<td>0,57</td>
</tr>
<tr>
<td>Chemicals</td>
<td>763</td>
<td>0,54</td>
</tr>
<tr>
<td>Plasticizers</td>
<td>269</td>
<td>0,26</td>
</tr>
<tr>
<td>Polymers</td>
<td>861</td>
<td>0,65</td>
</tr>
<tr>
<td>Accessories</td>
<td>52</td>
<td>0,33</td>
</tr>
<tr>
<td>Steelcords&amp;beadwires</td>
<td>910</td>
<td>0,36</td>
</tr>
<tr>
<td>TyreCordFabrics</td>
<td>63</td>
<td>0,22</td>
</tr>
</tbody>
</table>

\[ P = \frac{694 \times 0,57 + 763 \times 0,54 + 269 \times 0,26 + 861 \times 0,65 + 694 + 763 + 269 + 861 + 52 + 910 + 63 + 52 \times 0,33 + 910 \times 0,36 + 63 \times 0,22}{694 + 763 + 269 + 861 + 52 + 910 + 63} = 0,53 \]
In the end we get that total probability of get materials not on time is 0.53. Because of delivery on time will be early or later than expected, they will have different magnitude of consequences and we should to know the probability for each case. In accordance to practice half of situation delivery not on time is early and another part is later delivery. So let’s consider that probability of delays is 0.26 and early delivery - 0.27.

a) As already mentioned the worst effect could be production downtime. In 2014 delays in deliveries for the company were in place, but they did not lead to production stoppage. Possible problems purchasing group caught at an early stage and took countermeasures to speed up deliveries, as MRP allows seeing potential problems ahead of time. Based on these expert opinions, let's say 1:00 downtime costs 30 000 US dollars. The average rate of the dollar to the ruble equivalent to 38.37 rubles for one dollar, according to official data of the Central Bank of the Russian Federation. So magnitude of consequences in situation downtime production during one day:

\[
\text{MoC}_a = 24 \times 30 000 \times 38.37 = 27 626 400 \text{rub.}
\]

Then according to formula (13):

\[
\text{LoR}_a = 27 626 400 \times 0.26 = 7 182 864 \text{rub.}
\]

b) In case, if delivery will be early than expected date the magnitude of consequence will calculate in the next way. For calculating magnitude of consequence we used follow parameters:

- Purchasing cost in 2014 year was equaled 11 543 312 426 of rubles;
- The average key interest rate was 10.29% by official data of Central Bank of the Russian Federation (2014)
- The number of days of early payment is 1 day.

So, the

\[
\text{MoC}_b = \frac{11 543 312 426 \times 10.29 \times 1}{100 \times 365} = 3 254 265 \text{rub.}
\]

\[
\text{LoR}_b = 3 254 265 \times 0.27 = 878 652 \text{rub.}
\]

Costs. It is necessary to take on the staff of new employees - a specialist in risk management, which should provide a risk assessment according to this method, as well as monitoring and controlling all of the risks.

The average monthly salary was 45 000 rubles, including the income tax of 13%, which equals 5850 rubles, so the net average salary was 39 150 rubles. Thus:
\[ \text{CoL} = 45000 \times 4 \times 12 = 2160000 \text{rub.} \]

Also we need to organize work place (OWP), in table 16 is represented type of equipment and office machines for one work place.

Table 16 – Type of equipment and machinery required for 1 work place

<table>
<thead>
<tr>
<th>Type of costs</th>
<th>Costs, ruble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oracle e-Business Suite software licenses</td>
<td>348780</td>
</tr>
<tr>
<td>Furniture</td>
<td>12204</td>
</tr>
<tr>
<td>Personal computer, telephone set</td>
<td>58568</td>
</tr>
<tr>
<td>Operating system and Office software</td>
<td>19411</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>438963</strong></td>
</tr>
</tbody>
</table>

The costs of organizing of work place will be equal to total costs in table 16, i.e OWP=438963 ruble. All of the above in the table 16 costs are onetime expenses. These costs can be added to other costs, because considering only one year in which these expenses are made. As the expected economic efficiency will be high, it is possible to hold such enlarged calculation.

As the magnitude of the consequences of risk delivery not on time is very high and the probability is 0.53, then for this risk is necessary to adopt a strategy to «reduce». One of the measures is a constant control, which is already included in the new specialists in risk management.

Therefore, the costs are calculated on the following way:

\[
C = \text{CoL} + 4 \times \text{OWP} \\
C = 2160000 + 4 \times 438963 = 3915852 \text{ rub.}
\]

As later and early deliveries are not combined events the effect will find in next way:

\[
E = R - C = (\text{LoR}_a + \text{LoR}_b) - C = (7182864 + 878652) - 3915852 = 4145664 \text{rub.}
\]

And economic efficiency by formula (10) equal:

\[
\text{EE} = \frac{4145664}{3915852} = 1.06
\]
CONCLUSION

Developing methodology which is presented in given master’s thesis aimed to manage source risk in supply chain of N’ business. In the course of it developing the aim was achieved.

With the use of SCOR model was able to hold the decomposition of N supply chain and to get to the one of the «type of processes» - source. This process has been the object of master’s thesis.

Due to the lack of KPI interactions with suppliers and insufficient statistical information managed to hold non-complete risk assessment.

The reason that is not sufficiently succeeded to conduct a quantitative assessment of source risk is the low level of procurement maturity in Russian companies. According to research comparing the profiles for procurement conducted by KPMG, the maturity of procurement in the Russian companies is still from the first to the third level; while in western companies is from 4 to 5 levels.

In Russian companies on the one hand, the price of purchased goods and services plays a priority role in the selection of suppliers. On the other hand the actual trend is centralization of procurement procedures. In this direction procurement is often not recognized as strategically important. In western companies all the way around the structure of procurement are already moves towards decentralization and three-quarters of executives surveyed consider procurement issues important and very important – this suggests that the management understands the strategic importance of this issue.

If we take the N company it is stands to mention that the procurement organization is located at the commercial level. Despite the existence of purchasing policy, which has been used since 2014, the purchasing specialist the purchasing department mainly focused on achieving the lowest price.

Also the one of the profiles in comparison in the research was risk management in purchasing and it is it is interesting to note that in Russian companies’ insufficient attention paid to risk management in procurement.

So the development of risk management in procurement in the company should begin with the collection of data the already established and recreate KPI suppliers for calculation. Further, to ensure the continuity of supply takes place integration risk management procedures in the relationship with suppliers.

So in the obtained methodology represented a part of the KPI, which assesses the probability of operational risks, can be used to calculate the reliability, flexibility, and the cycle of the order of each supplier and the supply chain.
Thus, summing up, the done work, the developed methodology is not perfect, yet designed the structure to manage source risk and applied the idea to use SCOR model for finding quantitative indicators to risk assessment. Further use and improvement of methodology depends on desire by businesses to a more reliable relationship with suppliers.
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APPENDIX A. L&P STRUCTURE

Figure. L&P structure
Figure. Purchasing procedures