IOSUD - Polytechnic University of Timisoara
Doctoral School of Engineering Studies

CONTRIBUTIONS REGARDING THE DEVELOPMENT OF SUPPLIER RELATIONSHIP MANAGEMENT IN THE AUTOMOTIVE INDUSTRY

PhD Thesis - Abstract

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author eng. Gina PRODAN
scientific coordinator Prof.univ.dr.ing. Marian MOCAN

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This research topic follows the changes produced in the Romanian Automotive Industry, considering the various problems it faces in recent years (Covid 19 pandemic, semiconductor crisis, lack of production capacity of the supplier, excessive and frequent fluctuations in demand from customers, lack of storage capacity) and proposes a new method of evaluating suppliers.

The current problems in the Automotive and Components Manufacturing Industry are problems that the entities have had to deal with in the past, but on a much smaller scale. If until 2018 there were issues in terms of non-delivery of raw materials, starting with 2020 these problems have worsened. The simple fact that a supplier does not deliver an essential component (as the semiconductor is considered) has a major impact on the entire entity. In the situation in which only one component is missing the finished product cannot be made or, it will be an incomplete version. If that finished product is made on a dedicated production line, then the production will also be stopped. If the period during which the material is missing continues, there is a possibility of stopping the production line. Also, in the context in which the other suppliers deliver the orders in accordance with the requirements transmitted by EDI there will be an overcrowding of the warehouse. An increase of uncertainty level will augment in turn the employees' level of stress, which may lead to more human errors therefore a strain in problem managing. In this case, the emphasis should be on communication with all suppliers and the existing situations should be presented in a transparent manner in order to improve these situations.

If until now the price was the main criteria for selecting suppliers, their evaluation being done according to the clear requirements of ISO 9001: 2015, in the current situation, things changed drastically, and the biggest requirement of suppliers becomes the degree of flexibility concerning the delivery of raw materials.

Motivation: Until 3 years ago, all entities involved in the Automotive Industry allocated significant resources to reduce the stocks' level, there were numerous more or less feasible projects that tried to reduce stocks and improve relations with suppliers. At present, the continuing constraints of the supply chain when it comes to steel, semiconductors and transport in general have consequences for all entities. All these imbalances have led to undesirable effects: overcrowding of warehouses, shutdown of production lines, increasing the level of uncertainty, intensifying the special transports to customers, decreased profitability, and a lower degree of product availability.

If so far, agreements with suppliers have generally been negotiated in order to obtain the lowest possible price for the supplied products, the organizations making compromises regarding the location where the materials were procured (Malaysia, Singapore, Shanghai,

Plymouth, etc.) having a delivery time of 12 weeks, now the situation has changed, and the priority is the availability and flexibility of the supplier to deliver the materials.

The main objective of this paper is to improve the flow of communication with suppliers in the current conditions. This scientific research will highlight the negative effects produced by the Covid 19 pandemic and the semiconductor crisis on the Romanian Automobile and Auto Components Manufacturing Industry, a particularly important segment for the study due to its economic, social, and technological dimension. The main objectives are:

- framing the topic with a scientific approach;
- presentation of the direct impact on the automotive segment based on statistical worldwide data recorded in the period 2019 - 2021, in the European Union and Romania;
- identifying and presenting the main risks and negative effects on the elements of the supply chain caused by the pandemic and the semiconductor crisis;
- analyzing the flows of goods in the warehouses and making a comparison between the different types of warehouses;
- elaboration of a number of 4 distinct scenarios, possible within the deposits, and measurement of performance indicators;
- assessing the current state of relations that organizations maintain with their suppliers and improving the negative side effects of inadequate management;
- developing and testing a supplier evaluation model, aggregated by both parties, to improve the flow of communication with suppliers.

Considering the previously presented objectives, the paper has the following structure: introduction, five chapters specific to the researched field, conclusions, and bibliographical references.

In the second chapter, the general framework in which the research topic falls is presented in a concise form. The automotive industry is part of a well-structured system, based on clear regulations that operate according to standards imposed by the original equipment manufacturer. Today's companies have created global strategies to procure raw materials, components and labor from low-cost countries that are often located far from the countries they will be used in. [104] This means that they may have more options for selecting consumables and negotiating lower parts prices. Through this, they hoped to gain competitive advantages and secure sources of supply, but the great distance from suppliers and the complexity of logistics in global companies tend to create longer order delivery times and higher stock levels (which contradicts current requirements). Businesses need to practice cost-effective philosophies, with the main goal being to move towards shorter delivery times and eliminate excess stock levels. Therefore, a difficult task arises in fulfilling both objectives. [16]

In the context of aggravated uncertainty, suppliers must demonstrate their ability to manufacture and supply production parts that meet all relevant requirements when the customer needs them. [106] Thus, the concepts of flexible and reliable delivery have become essential for efficient production performance in all business lines, but especially in the automotive industry. Suppliers should generally ensure the availability of specific stock volumes at predefined times and locations. They must use the same computer system as the customer to track deliveries and synchronize inventory processing. [107] Globally synchronized cooperation and communication with suppliers is important for achieving economic goals. In addition to innovative delivery concepts, suppliers need to be able to realize classic concepts such as consignment stock, JIT and Kanban. [112] Requirements for suppliers are high and often change depending on the context, making their assessment considerably difficult. [17]

The third chapter presents the effects of semiconductor tires in the Automotive and Components Manufacturing Industry. The current lack of semiconductors is the result of a

combination of factors: a strong and accelerated demand for digital technologies, the long manufacturing life of the raw material that is in opposition to the JIT (Eng. Just in time-exactly on time), inflexibility and concentrated supply and in addition the COVID-19 crisis, as well as geopolitical tensions. Due to the widespread digitalization of the economy and society, the demand for semiconductors has grown sharply even before the pandemic (for example, in 5G phones and antennas, new video games, sensors and devices for the Internet of Things, etc.). The pandemic has exacerbated the situation and exposed the vital role of chips for modern economies and societies through a series of parallel developments. Semiconductor deliveries to Europe from East Asia have further slowed due to general supply chain problems caused by transportation restrictions imposed by governments around the globe to fight the pandemic. [28] Car manufacturers were among those who endured the brunt of the crisis. In early 2020, carmakers reduced chip orders as demand fell. Semiconductor factories have allocated the available capacity for IT equipment. [113] When vehicle demand returned at the end of 2020, semiconductor factories were operating at full capacity, leaving carmakers with waiting times of up to a year or more. As a result, several car factories were closed in Europe and around the world, and workers were laid off [76]. European carmakers have called for an increase in EU chip production capacity and a reduced dependence on foreign imports. [2. 3]

Today, the Romanian car industry produces predominantly for export and is controlled almost entirely by foreign capital. In order to benefit from low labor costs, companies have invested mainly in manual processes, with a low level of complexity and technology. Romania serves mainly as a platform for assembling products designed for western states. [84]

The semiconductor sector is characterized by an intense research and development activity, the companies reinvesting over 15% of their revenues in research in state-of-the-art technologies. Semiconductor production requires a large number of unique materials, chemicals and sophisticated equipment provided by specialist suppliers for each stage of the manufacturing process.

According to Business and Consumer Surveys (BCS) the material crisis has grown rapidly in importance during 2021, overcoming both the demand deficit and the labor crisis (FIG. 3.2) [129]

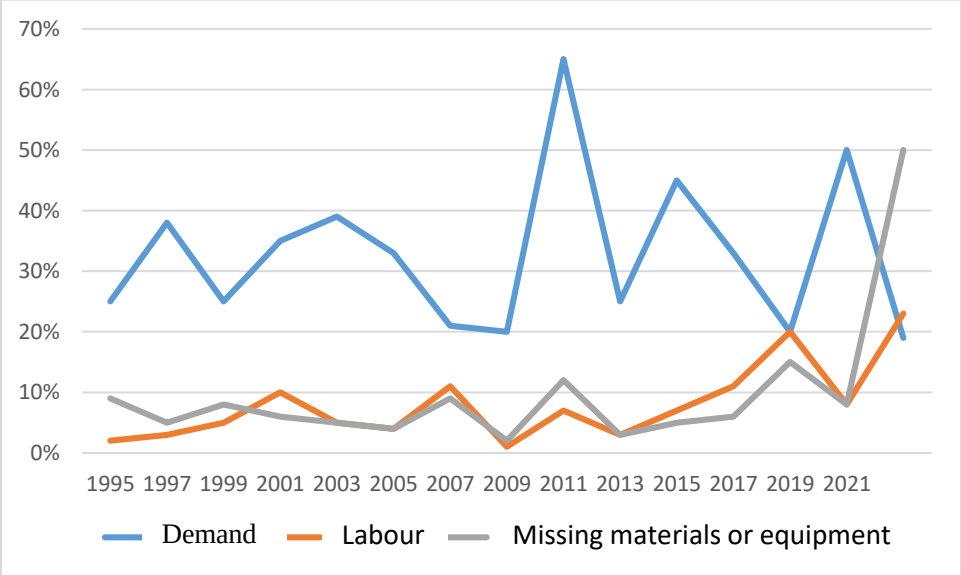

FIG. 3.2 - Factors limiting production in EU industry

In July 2021, the European Commission launched the Industrial Alliance for Processors and Semiconductors in order to identify current gaps in microchip production and technological developments needed for companies and organizations to thrive, regardless of their size. The

Alliance will help stimulate collaboration between existing and future EU initiatives, as well as play an important advisory role and provide a strategic roadmap for the Chips for Europe Initiative together with other stakeholders. [129]

Until now, 22 Member States have committed, through a joint declaration signed in December 2020, to work together to strengthen the European value chain of embedded electronics and systems and to strengthen peak production capacity.

The new measures will help Europe meet its 2030 digital decade targets of 20% of the global chip market share by 2030. [12]

After four months of substantial gains from March to June 2021 - the result of last year's low base of comparisons caused by pandemic bottlenecks - EU registrations showed a reverse trend in the third quarter of the year. [129]

The EU car market contracted by 23.1% in September, marking the lowest number of registrations for a month since September 1995. This drop in sales was largely due to the shortage of semiconductors. [12]

The substantial loss in September has also affected the EU's performance so far, which for the first three quarters now stands at 7.5 million units, up 6.6% from the same period in 2020. [130]

Significant gains since the beginning of 2021 have helped keep cumulative volumes in positive territory in three of the EU's four major markets. Italy recorded the highest increase so far (+ 20.6%), followed by Spain (+ 8.8%) and France (+ 8.0%). By contrast, the German car market slipped back into negative territory (-1.2%) (Table 3.2).

Table 3.2 - Top 4 countries registered in the European Union

Region	Jan - Sep 2020	Jan - Sep 2021	Changes percentage 21/20
Germany	2.041.831	2.017.561	-1.20%
France	1.166.698	1.260.373	+8%
Italy	966.335	1.165.491	+20.6%
Spain	595.436	647.955	+8.8%
European Union	7.526.613	7.057.927	+6.6%

Despite the stimulus of demand and the need to rebuild stocks after last year's blockade, production of passenger cars in the European Union still struggled to pick up, as the supply deficit deteriorated further during the year.

EU car production increased by just 3.1% in the first nine months of the year, reaching 7.6 million cars built, which is still 3 million units less than pre-crisis 2019 volumes.

Regarding the top 10 car-producing countries in the EU, production activity has slowed only in Germany (-4.7%) so far this year. The highest gains, on the other hand, were observed in Slovakia (+ 13.4%), Italy (+ 14.6%) and Sweden (+ 10.3%) (Table 3.3). [129]

Table 3.3 - Top 10 car manufacturers in the European Union according to HIS Markit

Region	Jan - Sep 2020	Jan - Sep 2021	Changes percentage 21/20
Germany	2.311.981	2.203.615	-4.7%
Spain	1.182.381	1.250.106	+5.7%
Czech Republic	789.720	830.163	+5.1%
Slovakia	656.639	744.338	+13.4%

France	584.050	638.122	+9.3%
Italy	290.161	332.427	+14.6%
Hungary	311.429	330.056	+6%
Romania	305.073	315.115	+3.3%
Sweden	177.490	195.787	+10.3%
Belgium	160.809	170.937	+6.3%
European Union	7.371.604	7.603.340	+3.1%

In chapter four are presented the notion of warehouse, traditional and semi-automated warehouse, as well as the impact that semiconductors lack has on industrial warehouses. Most of the time, when there is a delay in a material, there is a risk of overcrowding the warehouse. If, for example, the warehouse has a simple storage configuration with 200 pallet locations, the non-delivery of a material involves the occupation of 159 pallet locations (assuming that the warehouse is normally occupied at a capacity of 80%). Not having all the materials available, the production will not be able to produce the finished product and the materials will be kept on the locations in the warehouse. If the material delay persists longer and the other suppliers will send the materials according to the requirements sent by EDI, then the warehouse will become overcrowded, and the company will need additional space to store the new raw material. As the delivery time is 12 weeks most likely the next 12 deliveries are either in transit or awaiting the customs clearance process. In the current context, the storage models designed so far have become insufficient. Three different solutions are developed for these situations:

- increase the basic capacity to cover all peak demand throughout the year
- use of short-term rental of additional space in another external warehouse to add capacity for peak demand
- the use of on-demand storage at another warehouse belonging to the same concern to address both situations of insufficient capacity and overcapacity.

Making a comparison regarding the factors that led to the excess stock in warehouses between 2018 and 2021, significant increases are observed. (FIG. 4.9)

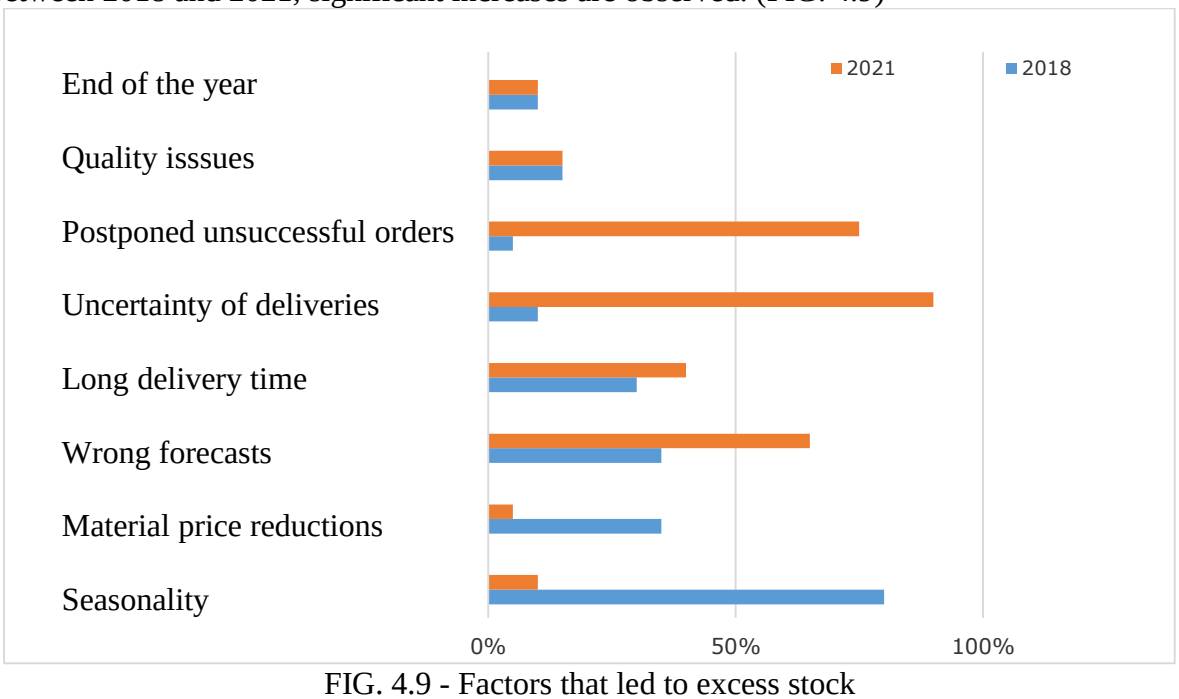

FIG. 4.9 - Factors that led to excess stock

The biggest differences are in terms of uncertainty of deliveries and postponement of orders in transit. If by 2018 the stock level exceeded the production capacity by up to 5%, in 2021 the situation changed drastically reaching 70%. (FIG. 4.10)

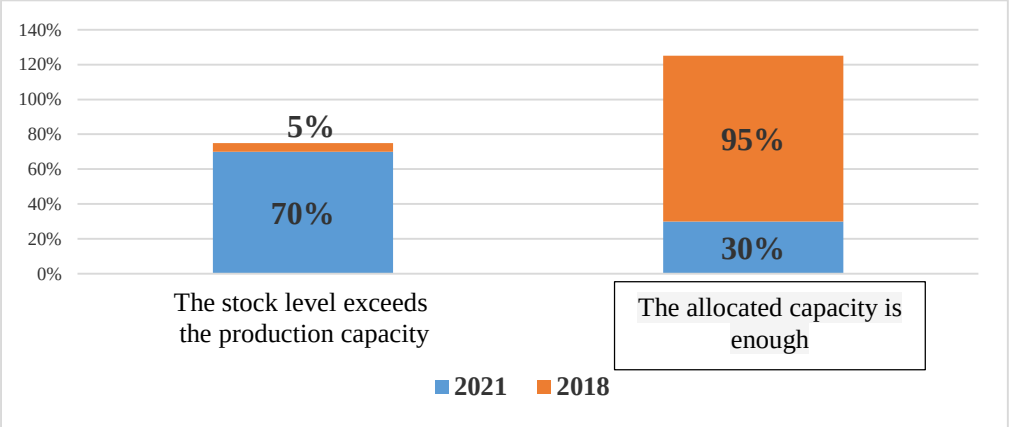

FIG. 4.10 - Warehouse capacity comparison

Until 2018, there were a maximum of 2 periods of 2-3 weeks in which the storage space was insufficient. However, in 2021 the situation changed reaching between 3 and 6 periods for 12 weeks. The figure below shows the difference in capacity for the same warehouse for 2018 and 2021. (FIG. 4.11)

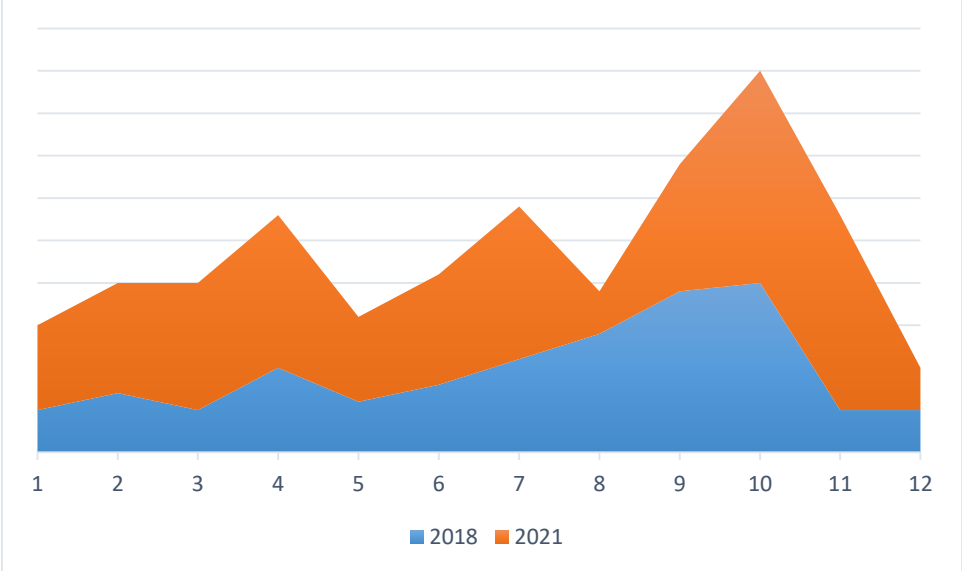

FIG. 4.11 - Occupied space in the warehouse 2018 vs 2021

Chapter 5 makes a comparison between the effects generated by the semiconductor crisis on the traditional storage and on the semi-automated storage. Through the Anylogyc program 2 scenarios are simulated:

- variable quantities delivered at equal intervals (normal case)
- variable quantities delivered at variable intervals (with delivery dates usually unknown)

For both scenarios the performance indicators are calculated, and the main differences are identifiedAccording to the results measured by means of performance indicators, a better management is observed within the semi-automated warehouses. In the case of both automated and traditional warehousing, the same kind of problems arise. Warehouse automation responds

to current needs: it replaces the human force (operator) that is difficult to find, certify and maintain, reduces operational costs, and increases efficiency. [115] On the other hand, the equipment acquisition cost is very high, and its amortization is done in more than 10 years. However, considering that the lack of labor in Romania has become a challenge for the labor market, automation helps greatly. [75] (Table 5.10)

Table 5.10 - Comparison of traditional warehouse with semi-automated warehouse

Evaluated indicators	Traditional warehouse	Semi-automated warehouse
Percentage of orders taken	< 81.4%	95%
Order picking accuracy expressed as a percentage	< 98%	99.5%
Percentage of shipment orders on time	< 95.9%	99%
Percentage of average storage capacity used	< 71.5%	85%
Percentage of annual labor turnover	> 12.2%	5%
Percentage of productive working hours	< 74.4%	85.1%
Number of lines supplied per hour	< 11.8 lines per hour	28 lines per hour
Pallets shipped per hour	< 6.2 pallets per hour	15 pallets per hour
Percentage of stock inventory accuracy	< 95%	99%
Cost as a percentage of sales	> 10.04%	3.9%
Degree of accuracy of suppliers' deliveries expressed as a percentage	< 90%	95%

With the global chip crisis lasting longer than originally expected players in the automotive industry have been forced to rethink their production strategies. Problems that have not existed before are arising now: overcrowding of warehouses with goods, increasing the level of stress in employees.

Chapter six presents how the "Evaluate your supplier" application was drawn and thought out. It is divided into 5 large sections in which details related to the general identification data of suppliers, their location, performance indicators as well as the evaluation section itself and the questionnaire section are presented. The purpose of the application is to provide transparency to suppliers about their work, to discover potential weaknesses and to develop strengths. Another goal is to propose solutions and alternatives to reduce or even eliminate existing weaknesses. With the help of the created application, long-term relationships with suppliers can be effectively developed. The most important objectives of the application are:

- transparent internal and external communication
- real-time traceability of weaknesses
- sustainability throughout the supply chain
- continuous improvement of the quality of services offered from a logistical point of view

The application can be downloaded from both phones using Android operating system and those using iOS. This application was created on the **openasapp.com platform** and is divided into several sections:

1. Suppliers

In this section you can view all suppliers and find general information about them such as: supplier name, logo, address, country of origin. The information appears as a list and with the navigation up and down you can view the complete list. Additionally in this section you can filter the information and view it according to certain criteria such as: country of origin, number of deliveries, space occupied in the warehouse, etc. The viewing mode can change and we can also see their data in the form of graphs. The figure below shows the display mode (FIG. 6.1):

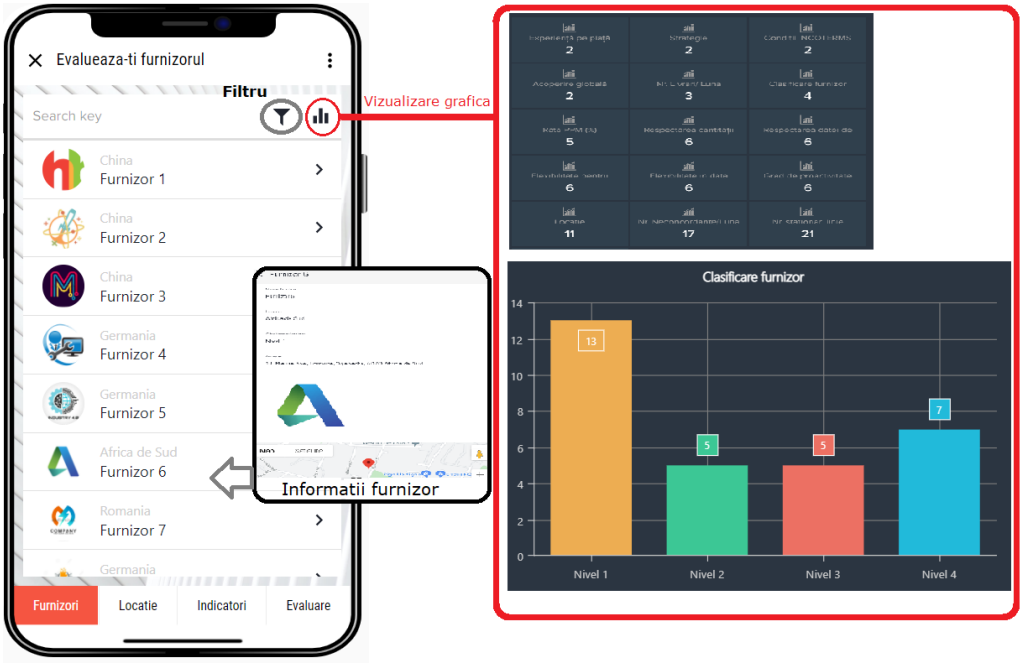

FIG. 6.1 View the Supplier section in the application

2. Location

In this section, the addresses of the suppliers are marked on the world map in order to have a better perspective on the distance between the supplier and the buyer. Google Maps data is used for more accurate information. The locations can be viewed in both map mode (MAPS) and satellite mode (SATELLITE), the images being taken from NASA satellites in 2022. Being interconnected with Google Maps all their updates are transmitted to the application through updates regularly. The figure below shows the view mode (FIG. 6.2):

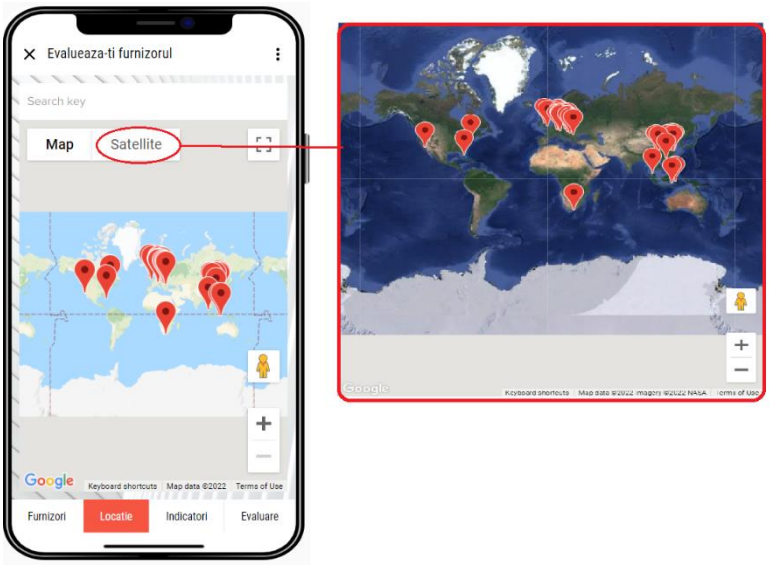

FIG. 6.2 View the section Location in the application

3. Key performance indicators

This section is the largest and most important section providing an overview of the vendors according to certain pre-established criteria. The information can be viewed in tabular form, list, or graphs. The most representative viewing mode is the one in the form of a graph (FIG. 6.3):

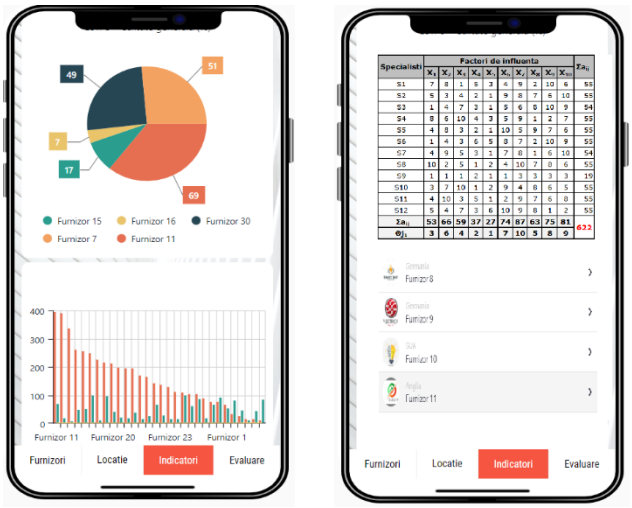

FIG. 6.3 View the section Key performance indicators in the application

4. Rating

Through this section, the supplier can be evaluated according to several main criteria as well as secondary criteria (FIG. 6.4).

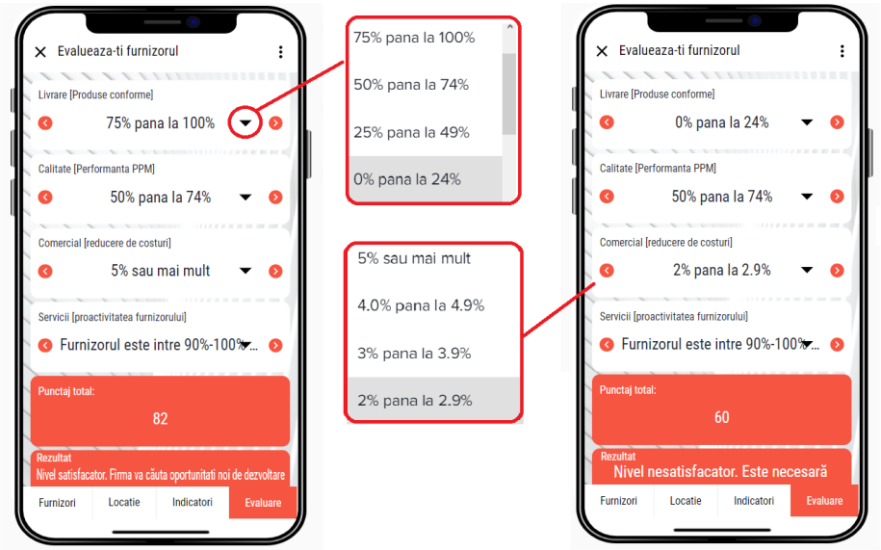

FIG. 6.4 - View Evaluation section from the application

5. Questionnaire section

Questionnaires can also be completed within the application. Response time is very short. When the questionnaire was completed, the user receives a notification to update the application. The questionnaire appears in digital format and after completion there is a button through the houses can be sent as a PDF to the creator. (FIG.6.5)

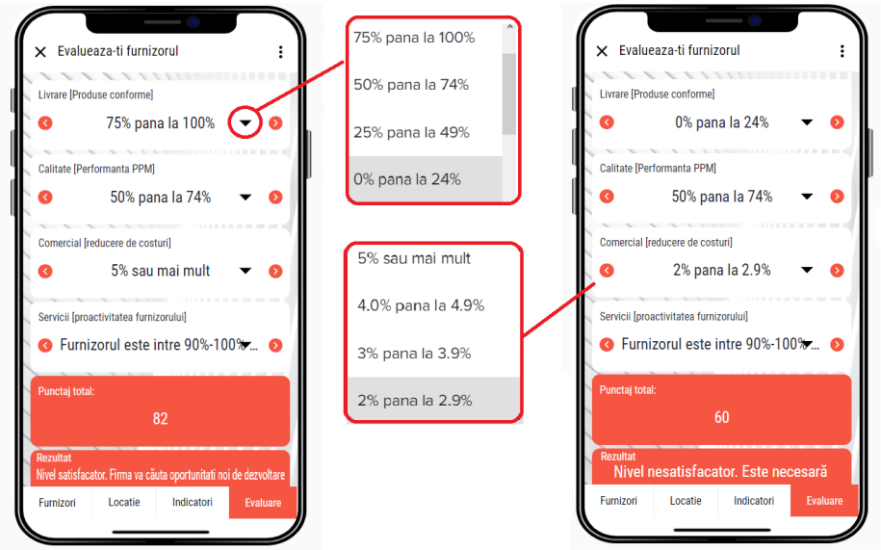

FIG. 6.5- View Questionnaire section from the application

The operation principle of openasapp.com site consists in transforming the Visual Basic programming language that underlies Excel into a proper application. The site interface is intuitive with elements on the right side through which data can be entered in the application. (FIG.6.6)

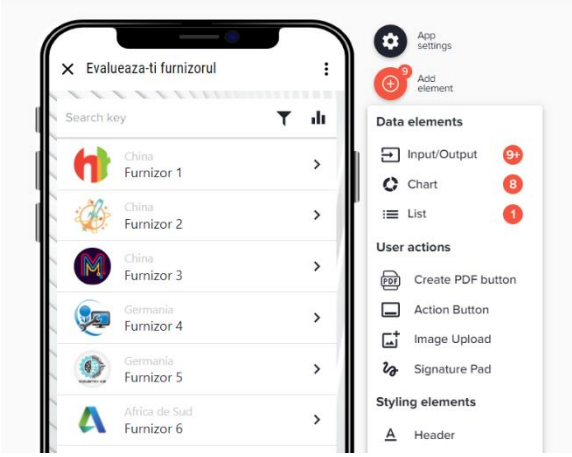

FIG. 6.6 View the openasapp.com interface

In the 'Evaluate your supplier' application, the graph is presented through a comparison is made between the number of orders delivered and the orders sent via EDI. The data obtained were generated through the SAP transaction called MB51 having completed the fields: factory (plant), supplier (eng. Vendor), type of operation (eng. Movement type) and time period (Posting data). (FIG. 6.7)

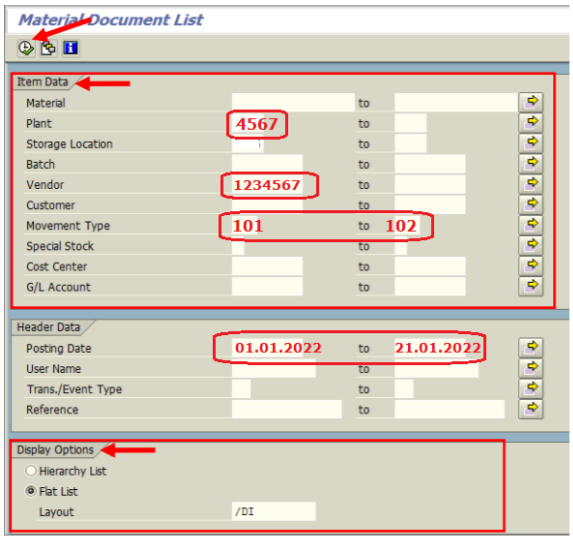

FIG. **Error! No text of specified style in document.**.1 View the transaction interface MB51

After the data has been generated, an excel table is inserted by selecting the data for the graph. The lines of code in generating an excel chart are:

```
"Sub Supplier Chart ()
Dim cht As Chart
Let's be The Series
Set cht = Sheets ("Sheet1"). ChartObjects.Add (0, 0, 300, 300) .Chart
With cht
.ChartType = xlBarClustered
Set ser = .SeriesCollection.NewSeries
With ser
.Name = "Average Delivery / Month"
.XValues = Array ("Vendor 1", "Vendor 2", "Vendor 3", "Vendor 4", "Vendor X")
```

```
.Values = Array (4498291, 4451255, 4160684, 3014186, 1889044)
End With
Set ser = .SeriesCollection.NewSeries
With ser
.Name = "Average EDI Commands / Month"
.Values = Array (5198291, 4851255, 4760684, 4014186, 1989044)
End With
End With
End Sub "
```

When the excel file containing the chart is uploaded to openasapp.com, it enters the chart into the application. (FIG. 6.8)

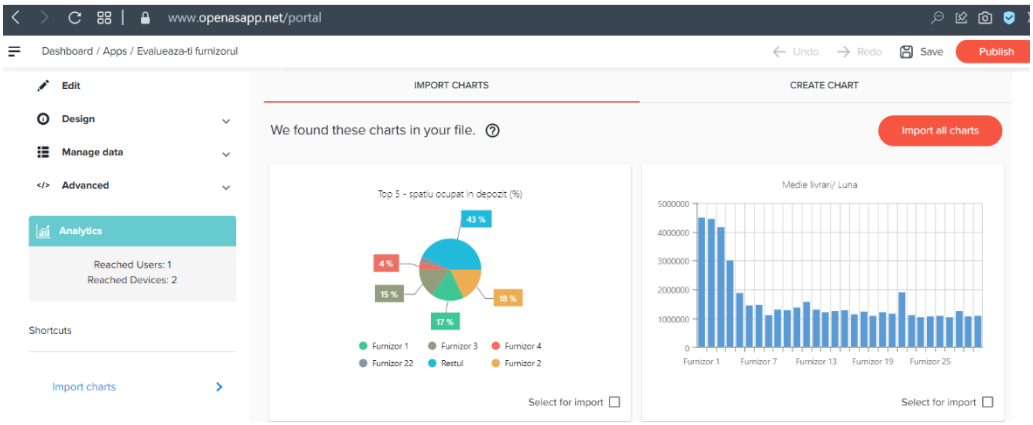

FIG. 6.8 View site openasapp.com-graphics loading section

Among the main advantages identified can be listed:

- the application can be downloaded on both phones that use Android operating system and those that use IOS
- the application interface is intuitive and easy to use
- ensures a competitive advantage in terms of costs, technology and minimum resources used
- everything that happens when a user enters the application is in accordance with the latest update
- the phone is available at any time, being one of the devices used daily
- updates can always be made, which provides a permanent traceability of weaknesses
- evaluation can be done much easier.

A major disadvantage would be that being exposed to the online environment the application can be infected, in the event that there is no antivirus program on the phone. Also, if your phone is connected to an unsecured wireless network, such as in restaurants or cafes, data in the application may be intercepted by others. There are many factors that can independently affect the user experience, including the speed of the internet connection, the reliability of the access network, the availability and upload characteristics of the application servers and, in some cases, the network configuration of the user's home. The application can be used for conducting quick surveys through the questionnaire section.

The main personal contributions presented in the paper are:

- Characterization of the automotive segment in the European Union and Romania;
- Analysis of the demand for cars according to the monthly statistical data from the

European Union and Romania for the period 2018-2021;

- Identifying and presenting the main risks and negative effects on the elements of the supply chain caused by the pandemic and the semiconductor crisis;
- Presentation of the direct impact due to semiconductor tires in the automotive segment based on statistical data recorded in the period 2019 - 2021 worldwide, in the European Union and Romania;
- Comparison between the effects generated by the semiconductor crisis on the traditional warehouse and on the semi-automated warehouse with the help of the simulation in the AnyLogic program;
- Presentation of the advantages and disadvantages for the 3 solutions applied so far in Romania in case of overcrowding of warehouses (increase of basic capacity to cover all peak demand throughout the year, use of short-term lease of additional space in another warehouse external to add capacity for peak demand, use on-demand storage at another warehouse belonging to the same concern to address both low capacity and overcapacity situations) in order to mitigate the effects of lack of semiconductors;
- Analyzing the flows of goods in the warehouses and making a comparison between the efficiency of the two types of warehouses;
- Elaboration of a number of 4 distinct scenarios, possible, within the warehouses, and measurement of performance indicators;
- Elaboration of a tabular model in which the performance of the warehouse operators can be measured;
- Elaboration of a tabular model through which it is possible to make a comparison between the workload in case of lack of materials and the workload after recovery;
- Assessing the current situation of the relationships that organizations maintain with their suppliers and improving the negative side effects obtained from inadequate management;
- "Evaluate your supplier" application. It is divided into 5 large sections in which details are presented related to:
  - general identification data of suppliers
  - their location,
  - KPIs
  - evaluation section
  - questionnaires.

- Development and testing of a real-time supplier evaluation model, agreed by both links of the chain, to improve the flow of communication with suppliers, through the method of rank correlation;

Proposals for future research in the field

The creation of the application appeared as a necessity in the current crisis. Upon receipt of the assessment information, the supplier shall begin to implement the corrective measures or requirements. Before analyzing how to implement, the provider must first know in detail what needs to be improved. Suppliers need to assess when they can meet the requirements and when they can come up with improvements. The application can be expanded by adding a status tracking section with real-time feedback improvements. Also in this section you can offer some advice and counseling for points where not everything is clear.

This study focuses mainly on the performance measured according to the performance indicators in the Automotive and Components Manufacturing Industry. This application can be customized to the needs of each enterprise in other similar industries. The only condition is to have quantifiable performance indicators.

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