ALLOCATION MEASURES IN A VOLATILE MARKET A STUDY CASE FOR SEMICONDUCTORS

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Abstract

This paper, motivated by the experiences of a major automotive company in Romania and has the purpose to analyze why the components enter in allocation to find the root cause to propose further improvement solutions.

This paper represents a study case regarding the process that it's followed by raw materials which enter an allocation.

This paper will focus on analyzing and answering one question, regarding the main cause for components to end in allocation process. The target is to define, which situation creates more challenging situations: poor planning or capacity constrains. The main questions that remain to be answered are regarding the definition of the steps to be taken for each of the scenarios analyzed: poor planning and capacity issues.

Keywords: allocation, inventory management, demand fluctuations, uncertainty

1. INTRODUCTION

The semiconductor crisis which affected over 169 countries worldwide, made us understand that we are currently in a volatile market where uncertainty is a decisive factor into taking decision regarding inventory management.As the crisis continues, companies around the world have developed different strategies to overcome the challenging situations, one of them being the allocation of critical devices in order to support different customers and not interrupt the production flow Starting with the definition of the allocation process, this is the action to distribute an amount of a resource assigned to a particular recipient.

Due to the crisis of semiconductors this was one of the strategies used by some suppliers of this devices to support the demands of more customers. Nevertheless, the allocation processes it is a two-sided sword, as it may support and help the manufacturing companies of semiconductors, and it may support the major customer, but for the small players, this approach may jeopardize their business.

As stated by Mallik and Harker (2004), we can define the allocation process with the liniarity of the information, and the product and manufacturing managers that have access to confidential information such as demands and capacities, should present the information in a clear maner in order to avoid the misrepresentation of forecasts.

In recent years, the automotive industry has faced a significant shortage of semiconductors, which are essential for various electronic components used in vehicles. This shortage, primarily driven by increased demand from other industries and disruptions in semiconductor manufacturing, has led to the allocation of available semiconductor supply among automakers. As a result, some manufacturers have prioritized the production of high-demand vehicles or models with higher profit margins, while others have had to reduce production or temporarily halt the production of certain vehicles.

As for the experience with an allocation process for a multinational company, this paper has the purpose the analyze are popping up in the allocation process and how can be avoided to have unexpected devices entering this process.

2. PREVIOUS RESEARCH AND LITERATURE REVIEW

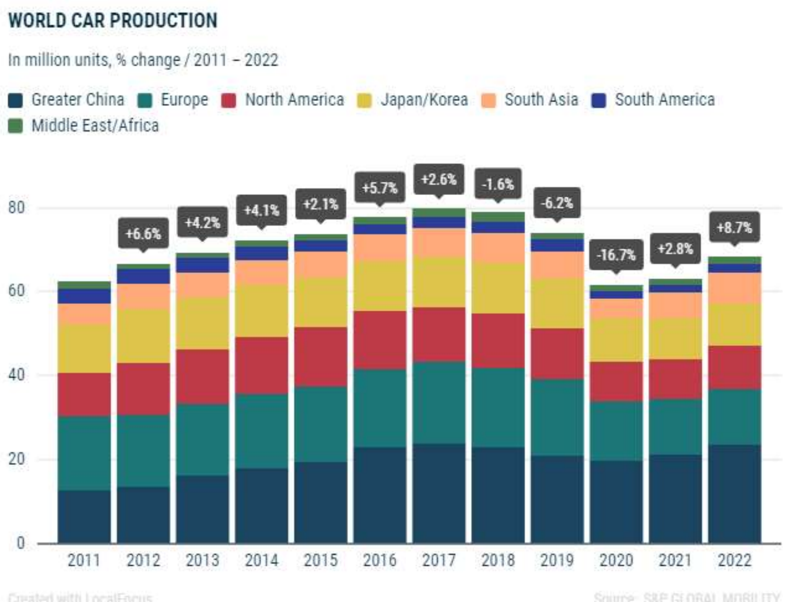
Accordingly, to East and Kaspar in an article for Industrial analytics platform,the actual status of the semiconductor chip crisis was caused by multiple factors in the early 2020s.The variability in the market and the complexity of the production, which was affected by the COVID-19 lockdowns, with the supply chain disruptions lead to an unstable situation at the manufacturing companies.These multi stage production processes, where for som suppliers, where for example for som suppliers the back-end process happens in one location and the front-end process is realised in another one, with extreme labour, are challenging and hard to maintain in challenging situation. The production capacities for the semiconductors are mainly in Taiwan, China and Republic of Korea, Japan, the United States and few in Europe.With the complexity of the process and the few available options for specific tehnologies, the criticality incresed over time, as the demands grew higher, and the production capacity stayed the same.

As visible in below figure, the world car production incresed yearly until 2019, where we have a decrese for two year in a row, this drastical change was based on the COVID-19. As we can see in the graphic, the decreasing trend was for the period when the pandemic was at his hight end. After the lockdowns and the situation was stabilized, as it is visible in the graphic, the production of the cars wordwide started to grow once again, being altmost at the same level, as before the pandemic. And so, only from 2021 to 2022, we are having an increase in car production of 8.7%. An increase which was redirected and transposed in the demands for the semicondutors.

Taking into consideration, the fact that the smartphone industry, had an highly increase over the last years as well, this also increased the demands for microchips, and split the capacity at some of the supplier for producing specific outputs for automotive and non-automotive usage.

Accordigly, to Mallik and Harker (2004), when such situation arise, when the demands keep on growing and where the capacity extension is expensive and time consuming, it is very common to go for an allocation process.

Figure 1 WORLD CAR PRODUCTION, In million units, % change / 2011 – 2022,

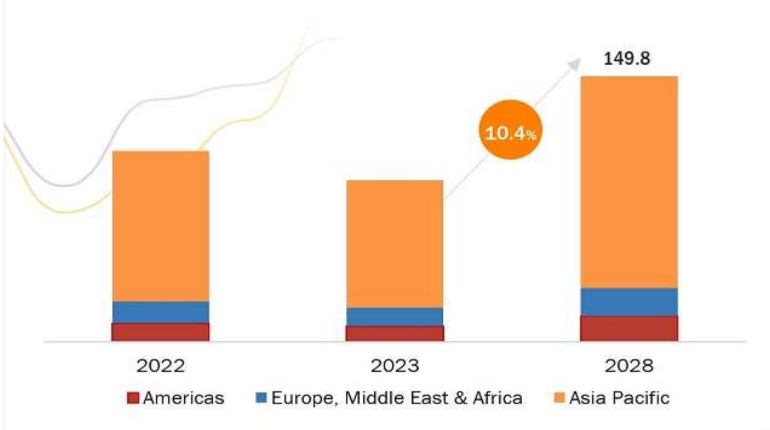


Source: ACEA, 2023

Accordigly, to Mallik and Harker (2004), when such situation arise, when the demands keep on growing and where the capacity extension is expensive and time consuming, it is very common to go for an allocation process.

The semiconductors market it is increasing acording to Markets and Markerts report, the goal to reach for 2028 it is USD 149.8 billion in manufacturing equipement, an increase of 10.4% of the actual status now in 2023, as visible in the Figure 2 below.

Figure 2 Semiconductor manufacturing equipment market, global forecast to 2028



Source: Marketsandmarkets.com (2023)

Even if the forecast it is for improvements, in the actual situation we are still facing challenging situation with the actual supply, which leads to follow several strategic options in order to prevent any types of disruptions in the production processes.

One of the strategic options companies are following as stated by Miller & Graham is to have a more selective view on the suppliers. Today we are having a lot of accesible platforms where we can monitor the score of the suppliers such as, for example, Z2data. For the scoring process are taken into consideration several different criteria such as: lead time, capacity constraints, price, tehnology, alteratives proposed by the same supplier, delivery in time.

As a completion on the above statement, we need to add the perspective from Yu et al. (2008), which stated that manufacturers are now in the search of improving the colaboration with the suppliers, to build up a partnership, in order to improve the performance.We can conclude here, that based on a good selection of the suppliers, we can select the competitives and trusthworty ones, and we can build up stronger partneships with the help of which we can fluidize the supply chain.

Overall, building partnerships with suppliers is about creating a collaborative, mutually beneficial, and resilient supply chain. These partnerships can enhance the competitiveness, reduce risks, and contribute to business's long-term success.

Another constrains that apear here is the bullwhip effect, which apears in the variability of the market, according to Cachon et al. (2007), it is affecting the whole supply plan from retail to manufacturing. This is where the uncerstainty it is build, based on the variability from customers we add variability to the supplier, taking into consideration the longer lead times that we are having today for such types of componets, adding variability only increases the risk of shortages.

In summary, the bullwhip effect can complicate the allocation process by introducing demand variability and uncertainty at different points in the supply chain. To address this challenge, companies often need to implement better communication and collaboration practices, invest in advanced forecasting and demand management tools, and adopt more flexible and responsive allocation strategies to adapt to changing demand patterns. Reducing the bullwhip effect can lead to more efficient and effective allocation of critical components and resources in the supply chain.

3. METHODOLOGY

3.1 Rules for entering in the allocation process.

In industry, the allocation of critical components refers to the process of determining and distributing limited or scarce resources, particularly those components that are essential for the functioning of various industries or sectors. These critical components can include raw materials, parts, or specialized components that are integral to the production or operation of certain products or systems.

The allocation of critical components is typically necessary during times of supply chain disruptions, such as natural disasters, economic crises, or geopolitical events that can impact the availability of key resources. In such situations, industries must

prioritize and allocate these critical components strategically to ensure continued production and minimize disruptions.
For every company the rules for some devices to enter into an allocation process may differ as the time frame for which an allocation should be kept it is defined by every business. Internally, it was defined that the allocation process often involves several key steps:

- Identification of critical components: Industries assess which components are essential for their operations and identify those that are most vulnerable to supply chain disruptions. These components could be sourced from a single supplier, have long lead times, or have limited availability.
- Prioritization: Once critical components are identified, industries establish a priority system based on factors such as the impact on production, customer demand, safety requirements, and contractual obligations. This helps determine which sectors or customers should receive the limited supply of components.
- Allocation strategy: Industries develop an allocation strategy to distribute the available critical components based on the established priorities. This strategy may involve allocating a percentage of the available components to different sectors, customers, or geographic regions.
- Communication and coordination: Effective communication among suppliers, manufacturers, distributors, and customers is crucial during the allocation process. Transparent and timely communication helps manage expectations, address concerns, and ensure a coordinated approach.
- Monitoring and adjustment: The allocation process requires ongoing monitoring of the supply chain and the availability of critical components. Industries must adapt their allocation strategy as conditions change, ensuring the most efficient use of limited resources.

For the company in cause the time horizon which a material it is kept in allocation it is one year, and the so named material enters the allocation when the coverage for it is under 13 weeks. The same methodogy is used for all components that enters the allocation process.

The coverage is given by the actual inventory, actual demands and confirmed delivery plan from the supplier, as calculated by formula (1).

$$Coverage = Actual\ Inventory + Confirmed\ delivery - Demands \quad (1)$$

So as a first rule, a material enters in allocation if the coverage it is lower than 13 weeks. The coverage may go under this green value (over 13 weeks) due do one of the following factors:

- The supplier does not have enough capacity;
- Insuficient orders/not enough capacity reserved at the supplier;
- Quality issues;
- Poor planning and poor mix optimization.

Despite the reason behind entering the allocation, another rule for this company is that the material will not be excluded from this process until the coverage is stable for the entire year. Once in allocation another golden rule it is to postpone or avoid, if possible, the customer impact.

The company the research was made on it is a multinational company, so it has worldwide site where finished goods are produced, in many cases, more than one site use the same raw material, for different project/finished goods and for different customers. As for that the first step is an internal allocation, and a fair distribution between the sites that are using the critical component, and further a distribution on projects and customers at the site level.

2.1.1 Distribution for the critical components

For the analysis we will take 4 components (A,B,C,D) from one of the supplier of semiconductors. These components are used in three sites on a different number of projects/final customers split as per bellow table no. 1.

Table 1 Split per projects

Site/Product	A	B	C	D
Site 1	4P	1P	1P	2P
Site 2	2P	3P	1P	4P
Site 3	1P	1P	1P	1P

Source: author

The P in the table it's noted for project, so based on that we can see that for examplethe raw material, A it's used in 3 diferent sites, in site 1 for 4 diferent projects, in site 2 for 2 different projects and in site 3 for only one particular project. Product B is used in 3 sites, for site A is used for 1 project, for site 2 is used for 3 projects, and for site 3 for 1 project. Product C is used in 3 site, and in each of them is only used for one project. Product D is also used in 3 sites, for site 1 for 2 projects, for site 2 for 4 projects and for site 3 in 1 project. Based on this table we can see, that mostly product A and D had the highest usage globally, both of them being used on 7 different projects. Also, for site 3, we can see that as for now they are only using the products for one projects, leading that this is a site with a low capacity for production, comparing with the other two sites.

The above split per project generates the demands for every site for every component. Based on that and taking into account the actual stock and future deliveries, we can calculate the coverage. In below table, will have a view an the actual situation for each site, for each of the mentioned products. With that we will have a line which will contain the actual stock existing in each site for each component. Another thing included into the view will be the demands per week, pieces needed generated by the production planning, which was also generated by customer orders. Another column in the table, it's stating the weekly deleveries, confirmed and aligned with the supplier for each of the four components. The orders for these devices were placed according to the lead time specifed by the supplier, and the quarterly volumes were splited weekly accordigly to sites demands. Having the current view, with the actual stock, actual demands based on the production planning and the weekly qty delivered per week as per bellow table no 2.

Table 2 Actual view for the components

Site	Product	Current stock	Demands/week (QTY)	Deliveries/week (Qty)
Site 1	A	256,000	76,000	26,000
Site 2	A	93,000	20,000	26,000
Site 3	A	27,000	15,000	26,000
Coverage all sites Product A				
Site 1	B	18,563	15,000	30,000
Site 2	B	88,761	15,000	30,000
Site 3	B	32,700	15,000	30,000
Coverage all sites Product B				
Site 1	C	10,000	5,000	5,000
Site 2	C	8,644	5,000	1,000
Site 3	C	5,469	2,000	4,000
Coverage all sites Product C				
Site 1	D	96,400	21,000	20,000
Site 2	D	154,600	45,000	30,000
Site 3	D	44,000	12,000	20,000
Coverage all sites Product D				

Source: author

Based on all the information above, we will calculate the coverage and will determinate a specific way of allocation. The deliveries are done based on the negotiations made by every site with the specific supplier. The coverage it is determined by the time frame a site can produce finished goods, without internal line downs based on the actual stock, demands and weekly consumption.

The red numbers in the table below, indicates when a certain site will face a challenging situation with one of the raw materials. By challenging situation, it’s understatable that the specific site can face internal line downs which is usually followed by stopping the customer production line, if some improvements in the supply plan received by the site are not performed.

Table 3 Coverage for all sites for all products

Site	Product	End week 1	End week 2	End week 3	End week 4	End week 5	End week 6	End week 7	End week 8	End week 9	End week 10	End week 11	End week 12	End week 13
Site 1	A	206,000	156,000	106,000	56,000	6,000	(44,000)	(94,000)	(144,000)	(194,000)	(244,000)	(294,000)	(344,000)	(394,000)
Site 2	A	99,000	105,000	111,000	117,000	123,000	129,000	135,000	141,000	147,000	153,000	159,000	165,000	171,000
Site 3	A	38,000	49,000	60,000	71,000	82,000	93,000	104,000	115,000	126,000	137,000	148,000	159,000	170,000
Coverage all sites Product A		343,000	310,000	277,000	244,000	211,000	178,000	145,000	112,000	79,000	46,000	13,000	(20,000)	(53,000)
Site 1	B	33,563	48,563	63,563	78,563	93,563	108,563	123,563	138,563	153,563	168,563	183,563	198,563	213,563
Site 2	B	103,761	118,761	133,761	148,761	163,761	178,761	193,761	208,761	223,761	238,761	253,761	268,761	283,761
Site 3	B	47,700	62,700	77,700	92,700	107,700	122,700	137,700	152,700	167,700	182,700	197,700	212,700	227,700
Coverage all sites Product B		185,024	230,024	275,024	320,024	365,024	410,024	455,024	500,024	545,024	590,024	635,024	680,024	725,024
Site 1	C	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Site 2	C	4,644	644	(3,356)	(7,356)	(11,356)	(15,356)	(19,356)	(23,356)	(27,356)	(31,356)	(35,356)	(39,356)	(43,356)
Site 3	C	7,469	9,469	11,469	13,469	15,469	17,469	19,469	21,469	23,469	25,469	27,469	29,469	31,469
Coverage all sites Product C		22,113	20,113	18,113	16,113	14,113	12,113	10,113	8,113	6,113	4,113	2,113	113	(1,887)
Site 1	D	95,400	94,400	93,400	92,400	91,400	90,400	89,400	88,400	87,400	86,400	85,400	84,400	83,400
Site 2	D	139,600	124,600	109,600	94,600	79,600	64,600	49,600	34,600	19,600	4,600	(10,400)	(25,400)	(40,400)
Site 3	D	52,000	60,000	68,000	76,000	84,000	92,000	100,000	108,000	116,000	124,000	132,000	140,000	148,000
Coverage all sites Product D		287,000	279,000	271,000	263,000	255,000	247,000	239,000	231,000	223,000	215,000	207,000	199,000	191,000

Source: author

The number presented in table 3, are the remaining quantities available at each site, at the end of each week, taking into consideration the actual stock, substracting the consumption and adding any deliveries recevaible for that week.

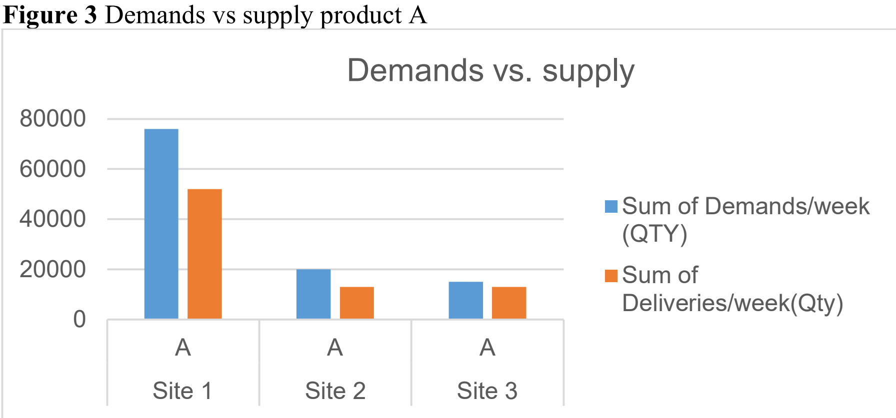
As visible in the table above, table no. 3 for product A, we are having a shortage in site A at the end of week 6, and increasing creating backlog, based on the demands and further deliveries, but for site 2 and 3 the situation it is stable, and overall the shortage should happen at the end of week 12, so following the rules of allocation a further balance should be made between plants. So by aligning with the supplier we will move some of the quantities destinated to site 2&3 to site, to prolong the impact for all the customers. By subtracting volumes from 2&3, we can prolong the impact until week 12 where the whole supply is insufficient to cover the demands, nevertheless we will gain 6 weeks in order to find other solutions to cover the gaps (pull-ins from the supply, search of alternatives, negotiations of capacity swaps).

In the above example we can see that product B started to recover since in allocation and it is building up stock, so if this product shows no criticality until end of year, and the tendency of building up stock remains, this component will be proposed for a swap of capacity with component A, reducing the supply here in order to increase product A supply. The same issues it is visible in product C, where site 2 goes into shortage by the end of week 3, while site 1 stock remains constant and site 3 stock builds up. As shown in the table above with a proper balance we can cover all the plants by moving volumes from supply from one site to another, with the concept of shared stock, and postpone the impact until end of week 13, where we will have a gap of almost 2,000. This week can be saved by a pull-in, but further the same as in product A, we need to find further solutions to improve the situation as we will only go in shortages based on the fact that the supply it is lower than the demands. For product D, as visible in the table, it is only a problem of balance, as the overall supply it is enough to cover all sites.

As visible in table 3. Coverage for all sites for all products, if the planning is poor for a single site, the situation, is, in most cases fixable wth a balancing between sites.But as seen in the cae for the product C, even if the shortages only comes from one site, as the other sites only work with a low level of stock (based on the price of this respective devices/most expensive one), the solution of balancing it is not enogh to cover all the sites. Here is a more challenging situation, were the first focus will be renogociating with the supplier the posibility to received in advance the supply available for the next week. Nevertheless, this is a short term solution which will only postphone the impact. Further will be analyzed the posibility of switching between capacity between components that share the capacity at the supplier, if were we have enough inventory or testing alternatives components.

These four components shows us the most common cases met in an allocation process. As visible in the below graphic, the main topic on why these products entered the allocation process is that the supply is lower than the demands.As we can see in the graphic below, for each site the demands for product A are higher than the deliveries confirmed by the supplier.

Figure 3 Demands vs supply product A



Source: author

It is a common case for the products in allocation that the supply it is not high enough to cover our demands, and the main root cause for this is either capacity issues and constrains at the supplier, or poor planning and negotiation for the volumes required.

In the first case scenario we have no input, when it comes to adding capacity in the production of semiconductors that it is a difficult topic which requires time and financial efforts from the suppliers, and these are topics in which we can not be directly involved in.

Nevertheless, for the second case scenario, where the poor planning and negotiation for the volumes required where mistaken by us, here it is still room for improvement. In below table, was calculated the difference between demands and supply, marked with black are the products were the demands was higher than the supply, and market with red are the products where the supply can cover the demands. As shown in the table bellow some site required the quantities that they needed but some did not.

Table 4 Difference between demands and supply

Site	Product	Demands-Deliveries
Site 1	**A**	**24,000**
Site 2	**A**	**7,000**
Site 3	**A**	**2,000**
Site 1	**B**	**(15,000)**
Site 2	**B**	**(15,000)**
Site 3	**B**	**(15,000)**
Site 1	**C**	**0**
Site 2	**C**	**4,000**
Site 3	**C**	**(2,000)**
Site 1	**D**	**1,000**
Site 2	**D**	**15,000**
Site 3	**D**	**(8,000)**

Source: author

By the difference between demands and supply we can get overall an idea if the planning was poor or some other issues were responsible for the parts to be in allocation. For the numbers marked with red in the above table, means that the supplier overdelivered our actual demands, enough to build us a buffer. We can see that the planning for site 3 was almost enough to cover all the components, with a little gap only for product A, where all the sites did not plan enough volumes in order to sustain their demands. We can also see in the above table, that for product B all the sites have done a proper planning in correlation with their actual demands. This is also visible in table number 3: Coverage for all sites for all products, product B it is the only products that in the overview for 13 weeks builds up stock. For product where all the sites requested less quantities than their actual requirements we can see, that this also affect the overall coverage ending up with a shortage of over 50,000 pieces at the end of the 13 weeks. For product C it is both a combination of poor planning and capacity constraints on the supplier side, which also translates to shortages.

The poor planning comes from uncertainty, from the fluctuations in the supply chain, mainly the side effect of the bullwhip effect, defined in chapter 2.

Taking into consideration the bullwhip effect, we are returning to the first premises that we are in a volatile market, subjected to changes, changes that affect the flow of the production and generates uncertainty. As demand signals become distorted and amplified as they move up the supply chain, suppliers often experience erratic and unpredictable orders. This makes production planning and scheduling difficult, as suppliers have to respond to surges and drops in orders. Taking into account all the information's shared above, the allocation process for products it is a tool used to improve the coverage of all sites using a certain type of raw materials.

3. CONCLUSION

In conclusion, the present paper has shown that the main problematic issue when it comes to why some products enter into allocations it is poor planning followed by the capacity constrains of production at the suppliers.Both situations analyzed, were impacting the manufacturing process, nevertheless in the case presented the poor planning had a bigger impact, and the process of monitoring them under the allocation was more challenging.

It is important to note that the allocation of critical components is typically a temporary measure to address supply chain disruptions. Industries strive to restore normal operations and diversify their supply chains to mitigate future risks, reduce dependence on limited sources, and enhance resilience.

Overall, the allocation of critical components plays a significant role in minimizing the impact of supply chain disruptions on industries, enabling them to continue operations and meet the demand for essential products or services.

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