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Exam pin-code: 37641

Q1 - Multiple choice

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Q2 - Semi-structured V1

$$EOQ = \frac{\sqrt{2DS}}{H}$$

$$I_2 = \sqrt{\frac{n_2}{n_1} * I_1}$$

$$ROP = \bar{d}\bar{L} + SS = \bar{d}\bar{L} + z\sqrt{\bar{L}\sigma_d^2 + \bar{d}^2\sigma_L^2}$$

a) Apply a useful method to get an idea how to improve the spare part management of RF based on the figures depicted in Table Q2.1. Do the necessary calculations and interpret the results!

Spare Parts	Repair Cases per Year	Demand Variance (per day)	Unit Price in DKK	Minimum Order Quantity	Order Price	Repairs per day (252 days)
Power Socket	360	2,72	105	100	10500	1,4286
Ram Module	31	2,04	560	1	560	0,1230
SSD Drive	288	1,74	735	1	735	1,1429
Mainboard	72	0,11	1540	1	1540	0,2857
Keyboard	108	0,3	420	1	420	0,4286
Screen	144	0,44	1890	1	1890	0,5714
USB Module	240	1,21	315	10	3150	0,9524
Wifi Module	156	0,51	245	10	2450	0,6190
Total	**1399**					
Average	**174,875**	**1,13375**			**2655,625**	**5,5516**

To minimize RF's orderings costs, it is crucial to find the Economic Ordering Quantity (EOQ). This helps us find the point in which RF minimizes their holding costs without increasing their order processing costs. The total demand per year is given by table and is the sum of all "Repair Cases per year", which sums to 1399. The average cost to place an order is 2655,625, which is the average of unit price times minimum order quantity. Since there are no transports costs, no more is added to the cost to place an order. As no holding costs have been given, we assume a holding cost of 50% of the ordering price to be able to continue.

$$EOQ = \frac{\sqrt{2 * 1399 * 2655{,}625}}{\frac{2655{,}625}{2}} = 37{,}40$$

This gives us an Economic Ordering Quantity of 37,4, which means that ordering the specified amount will minimize both holding costs and order processing costs. In real life, we would need to find the actual holding costs to be able to use this metric.

b) Given your results in a), please elaborate what may be an efficient inventory and ordering strategy for these spare parts RF needs for hardware repairs!

An efficient ordering strategy would be the Reordering Point as it is a continuous ordering strategy that takes variance in lead time and demand into account. Implementing it will make sure that RF orders at the right time with safety stock considered. The formula is given by:

$$ROP = \bar{d}\bar{L} + SS = \bar{d}\bar{L} + z\sqrt{\bar{L}\sigma_d^2 + \bar{d}^2\sigma_L^2}$$

The average demand per year is 174,875 or 0,69 per day of a 252 day year. The average lead time is given as 2. The variance in demand during the time period is calculated as 1,13375. As no variance of lead time is given, we assume 0. And lastly, we choose a service level of 99% as he per contract must be able to repair within 24 hours of receiving the PC. Thereby, we can calculate the ROP. First, we calculate the safety stock.

$$SS = 2{,}33 * \sqrt{2 * 1{,}13375} = 43{,}57$$

RF must have a safety stock of 43,57. This can be used to calculate the ROP:

$$ROP = 0{,}69 * 2 + 43{,}57 = 44{,}96$$

As the service level has been set to 99%, we incur a very high safety stock. If decided that the service level of 95% is sufficient, a safety stock of 30 would be needed, reducing the holding costs and ROP.

The ROP would ensure that they are always able to meet their demand and uphold their contract, making sure that they don't hurt their relationship with their current customer(s). Using our previously calculated EOQ, we know that they should order 37,4 units whenever stock hits 44,96.

We might also look into classifying the different products to see if we can find the Pareto Principle. To do this, we will conduct an ABC-analysis. Assuming that all repair components produce the same "markup", I will use the unit price to calculate the consumption value. Furthermore, I will use repair cases as the volume.

Spare Parts	Repair Cases per Year	Demand Variance (per day)	Unit Price in DKK	Minimum Order Quantit	Total consumption value	% TCV	% Cumulative TCV	% Volum	% Cumulative volume	Class
Screen	144	0,44	1890	1	272160	34%	34%	10%	10,3%	A
SSD Drive	288	1,74	735	1	211680	26%	60%	21%	30,9%	A
Mainboard	72	0,11	1540	1	110880	14%	74%	5%	36,0%	A
USB Module	240	1,21	315	10	75600	9%	83%	17%	53,2%	B
Keyboard	108	0,3	420	1	45360	6%	88%	8%	60,9%	B
Wifi Module	156	0,51	245	10	38220	5%	93%	11%	72,1%	C
Power Socket	360	2,72	105	100	37800	5%	98%	26%	97,8%	C
Ram Module	31	2,04	560	1	17360	2%	100%	2%	100,0%	C
Total	1399				809060	100%		100%		

After conducting an ABC-analysis, we find that 74% of Total Consumption Value (TCV) comes from 36% of repair cases. These items are classified as A items. 15% of TCV comes from 25% of repair cases, "B" items, and 12% of TCV comes from 29% of repair cases, classified as "C" items". This clearly shows a Pareto Efficiency where most value comes from fewer cases.

We notice that the most of the items with bigger minimum order quantities provide lower TCV and are ranked lower. Thereby, we might think about differentiating how our ordering strategies are for these items compared to our strategically more important "A" items. As ROP is a continuous method and thereby requires more resources, we might look into employing a periodic method for the less value providing items that have higher minimum order quantities, as they also greatly impact the current ROP.

c) What else could you suggest Alfred to improve his service operations?

Alfred might look into outsourcing to other suppliers for the items that have a huge minimum order quantity as they greatly affect the calculated ROP and EOQ significantly, and thereby might skew the results to be imperfect.

Lastly, we might also look into cutting down on warehouses. As of now, Alfred has 4 warehouses. It is smart as it provides close access to the main cities in Denmark. However, it also requires him to have safety stock at each warehouse, which means higher holding costs. If he holding costs outweigh the benefit of having 4 warehouses, we might look into removing some. The effect of this can be calculated using the Square Root Rule with the required inventory, current warehouses and future warehouses. We assume that the required inventory on stock is the previously calculated safety stock of 43,57. Assuming that he is to remove one warehouse, from 4 to 3, we can calculate the following:

$$Four\ warehouses: I_2 = \sqrt{\frac{n_2}{n_1} I_1} = \sqrt{\frac{4}{4} * 43{,}57} = 6{,}6$$

$$Three\ warehouse: I_2 = \sqrt{\frac{n_2}{n_1} I_1} = \sqrt{\frac{3}{4} * 43{,}57} = 5{,}71$$

The Square Root Rule tells us that the fewer warehouses you have, the less required inventory is needed. This is also proven as we move from 4 warehouses to 3. This way, we can decrease required inventory and henceforth, cut holding costs.

Q3 - Semi-structured V2

a) Please suggest and calculate some key performance indicators that enable a comparison between Boeing and Airbus from a supply chain management point of view!

To enable a fair comparison between Boeing Inc (BI) and Airbus SE (AS) from a supply chain perspective, I will calculate their Cash-to-Cash (C2C) Cycle and Inventory Turnover. The C2C cycle is a measurement that tells us about the efficiency of a company's inventory management. It tells us how many days it takes for the respective company to turn cash into raw materials into sold finished goods and received cash. Thereby, it reflects the overall efficiency of the whole supply chain. It consists how efficient it is at minimizing items in inventory, shown by the Days Inventory Held (DIH) metric. Furthermore, it tells us how well it is at collecting cash (receviables) from its customers via the Days Sales Outstanding (DSO) metric. And lastly, it shows how well they are at negotiating favorable contracts with suppliers in the Days Payables Outstanding (DPO) metric.

To get started, I will define the C2C Cycle:

$$C2C = DIH + DSO - DPO$$

I will calculate each metric for both companies subsequently

$$DIH = \frac{AVERAGE\ INVENTORY}{COGS} * 365$$

$$DIH_{AS} = \frac{59393777}{58758401} * 365 = 368{,}94$$

$$DIH_{BI} = \frac{79741000}{68209000} * 365 = 426{,}71$$

This tells us that AirBus on average holds its inventory for 369 days, whereas Boeing Inc holds it for even longer at approx. 427 days. This however is to be expected as airplanes are massive products and require lots of parts and assembly to complete as well as quality inspections before being sold.

$$DSO = \frac{AVERAGE\ RECEIVABLES}{REVENUE} * 365$$

$$DSO_{AS} = \frac{5242122}{72586378} * 365 = 26{,}36$$

$$DSO_{BI} = \frac{11055000}{77794000} * 365 = 51{,}87$$

Our calculated DSO shows that AirBus SE is almost twice as fast/effective at collecting cash from customers as Boeing Inc is at 26,36 and 51,87 days, respectively.

$$DPO = \frac{AVERAGE\ PAYABLES}{COGS} * 365$$

$$DPO_{AS} = \frac{43476245}{58758401} * 365 = 270{,}07$$

$$DPO_{BI} = \frac{1672000}{68209000} * 365 = 8{,}95$$

Lastly, AirBus SE shows fantastic numbers compared to Boeing Inc when it comes to DPO as they on average wait 270 days before paying suppliers back whereas Boeing Inc only has 9 days to pay back.

With the three metrics calculated, we can finally find the C2C Cycle:

$$C2C_{AS} = 368{,}94 + 26{,}36 - 270{,}07 = 125{,}24$$

$$C2C_{BI} = 426{,}71 + 51{,}87 - 8{,}95 = 469{,}63$$

The final results show a definitive winner when it comes to C2C as AirBus SE is almost 4 times as effective at turning Cash to raw materials to sold finished goods (Cash) as Boeing Inc.

Inventory turnover ratio (ITR) is another useful indicator that simply tells us how many times per period a company is able to turnover its inventory. It is the inverse of the Days Inventory Held. As a rule of thumb, an ITR of 10 is considered great for most companies. However, given the industry and as mentioned earlier, we can expect to see very low ITR for both companies. This doesn't show bad performance, but most likely reflects the general industry of airplane manufacturing. However, we don't have numbers about the industry to confirm or deny that.

$$ITR = \frac{COGS}{AVERAGE\ INVENTORY}$$

$$ITR_{AS} = \frac{58758401}{59393777} = 0{,}989$$

$$ITR_{BI} = \frac{68209000}{79741000} = 0{,}855$$

b) According to the given figures, which of the two companies performs better and why?
According the given figures and my calculations in a), it is clear that AirBus SE performs better with a multitude of reasons. First of all, AirBus' C2C cycle shows how they're 4 times as efficient at converting their investments in raw materials to sold finished goods as Boeing Inc. This is mostly attributed to AirBus' ability to minimize DSO and maximize DPO. This means that they are effective at making customers pay quickly and most likely have negotiated very favorable contracts with strategic suppliers or even integrated with them to ensure alignment of strategies, resulting in long payback times. The inventory turnover ratio of the two also show that AirBus is more effective.

Looking at the other given figures, we might notice that AirBus SE has a significantly lower working capital than Boeing Inc, which might insinuate that AirBus ability to respond (agility) to new orders is better as they have less capital tied up in other ongoing operations. Furthermore, following the Kraljic Matrix, AirBus has outsourced roughly 80% of the production of its aircrafts to thousands of suppliers worldwide, showing that they are able to leverage many suppliers to increase competition, which might help significantly lower their COGS as they sell more airplanes than Boeing Inc, 735 compared to 528, at a lower COGS of 58 million to 68 million, respectively. This makes sense as their aircrafts are their main product and therefore might be assumed to have high profit impact. However, as there are thousands of suppliers in the industry, the supply chain risk is assumed to be low. Therefore, the correct strategy to follow is to leverage suppliers, which AirBus seems to have done.

c) What could the other company do to get better?
The other company, Boeing Inc, have many possibilities to look into to improve the efficiency of their supply chain and decrease costs. Referring back to the C2C cycle, it is evident that Being Inc. might look into ways in which they can reduce the DSO as they on average wait approx. double the time that AirBus does. This can be done by analyzing their whole customer base and via the Pareto Principle, find the 20% slowest customers that might account for 80% of the slowest payback periods.

Additionally, they might look their suppliers, which mostly are situated in the US, while some come from China, to find a way to prolong their DPO. There are two main opportunities to consider. Firstly, they might look into renegotiating their contracts with their current suppliers or finding a way to

integrate further with them, so that their strategies might align. Secondly, they might take inspiration from the current winner, AirBus, who has chosen to outsource and leverage thousands of suppliers worldwide to handle 80% of their production, which is assumed to be cheaper than to have manufacturing, assembly and suppliers mostly in a higher cost country. By leveraging many suppliers and creating competition between them, they might be able to negotiate improved contracts with longer payback periods.

Q4 - Essay

To understand what fundamentally characterizes supply chain management and what differs it from older management approaches to design and execution, we must first understand the definition of logistics, supply chains and supply chain management.

Logistics is the planning, implementation and controlling procedures of efficient and effective transportation and storage of goods and services from the point of origin to the point of consumption while conforming to consumer expectations. In contrast, supply chains are defined as the upstream and downstream activities from the raw materials to the end-consumer. Lastly, supply chain management is management, such as integration and coordination, across and within a network of upstream and downstream organizations, of both relationships and the flow of materials, information and resources. Supply chain management takes a much more holistic view of an organization and all its activities and focuses more on relationships instead of transactions. This is different compared to the older management approaches that followed a more functional view, where each part of the supply chain operated as its own entity, often without complete integration and alignment to the strategy of the organization. In the traditionalist view of logistics and supply chains, the latter was part of the logistics. However, in the newer unionist perspective, we see logistics as part of supply chain management.

Globalization and digitalization are two drivers that have enabled global supply chain management to rapidly evolve during the last decades. Globalization has in short lowered barriers between nations and allowed for easy movement of resources. This is backed up by Friedman's theory of the "Flat World" that looks into how the distances across the world has "disappeared", and that we now easily can place factories anywhere in the world. Furthermore, digitalization, a global phenomenon, has also affected GSCM as IoT, systems of systems and blockchain technologies significantly improves the processing power and handling of complex structures, so that it has become "easier" or at least more realistic for supply chain managers to oversee otherwise unthinkable supply chain configurations.

One of the major supply chain configurations that were introduced was the Toyota Production System, developed by the car company Toyota, which later became the lean supply chain. Using the lean approach, Toyota (and other companies) have been able to eliminate unnecessary wastes, called the 7+1 muda, to minimize logistics costs, such as warehousing, greatly. This was done through methods like Kanban and JIT inventory management that ensured that inventory was only ordered when needed. However, lean supply chains don't allow well for unpredictable demand and are more prone to the bullwhip effect. With COVID-19 and recent outbreaks of wars, supply chains have been shaken to their core all over the world, proving that many or most were not configured to be able to withstand such change in the environment. Therefore, more and more companies have seen a need to become agile in order to increase resilience to outside shocks, as also mentioned in a report by EY (2022).

A great example of a company following the agile configuration is the clothing manufacturer, Zara. They have created an extensive network of suppliers, globally, in which they can leverage to quickly adapt to changes in the market. Since they operate in the fast fashion industry, demand almost changes by the week and subsequently, they must be able to respond to demand changes rapidly in

order to succeed. They receive a lot of generic goods from their suppliers in which at a late decoupling point, they customize to fit each country's fashion trends. Zara follows Glocalization in the sense that much of what they produce is the same, but depending on the market, they provide a different collection. Lastly, you might also look into the leagile configuration, which combines the lean supply chain with the agile, in order to minimize wastes and improve resilience and agility.

However, it is important to note that even though many companies are switching from lean to agile to become more resilient, there is no "one size fits all"-solution. Depending on the industry, market, political situation etc., the right configuration must be made by taking account all these factors and more.

What has enabled many of these configurations are advanced Warehouse Management Systems as well as MRP and ERP. Automatic warehouses and dark stores with automatic storage and retrieval systems has been set in place. Furthermore, as e-commerce has become more and more present, many organizations such as Walmart or Pandora have been able to create omni channels that interlinks all aspects of the business so the customer easily can connect with the firm at any point. Walmart was forced into this by the Covid-19 crisis and it was their agile response to introduce online ordering and curb-delivery, but it has now proven to be a successful endeavor.

To build further upon the world's political instability, we might see organizations reconfigure their supply chains further, by continuing to reshore and nearshore as they've already done the past years. An example is the China-Taiwan tensions, where many micro-chip companies quickly scrambled their operations and looked to reshore or nearshore their operations. Furthermore, the Russia-Ukraine war also challenged supply chain managers of i.e. energy companies, when sanctions were introduced. The companies that were the fastest at reconfiguring their supply chains and sourcing new suppliers proved to be the winners in the industry, again proving how an agile configuration might be of high importance in this unpredictable market.

Sustainability is also another key challenge for many companies as both stakeholders and shareholders all around the world increasingly demand it. Many companies have looked into optimizing their supply chains by either introducing reverse-loop logistics, looking into new fuel solutions for shipping and many more. Novo Nordisk, a great example of a company introducing reverse-loop logistics, piloted a project in 2020 about recycling their diabetes pens, which mostly consisted of plastic, metal and glass - recyclable materials. This can be classified as an open-loop system as they find another use for them. It has been very successful and they are slowly rolling it out on a global scale. On the hand, we have Maersk that is looking into other solutions for fuel such as E-methanol, to minimize their global carbon footprint.

The future will with a high probability still be filled with extreme uncertainty and volatility as well as demanding requirements from stakeholders and shareholders. Therefore, Global supply chain managers must have a "T"-profile in order to really be able to understand and handle supply chain risk management, and agile/leagile supply chains might still be the preferred configuration for many organizations.

Furthermore, as digitalization, blockchain and AI develops at a pace faster than we've ever seen, much is unknown of how the world will act. Is there a limit to the complex networks of supply chains that are scattered across the world? Or will technology keep improving and find optimum solutions for each part of supply chains in order to minimize costs and maximize efficiency, or even find new ways to transport goods in which we don't know of yet?