Assignment Brief and Front Sheet PGT

This front sheet for assignments is designed to contain the brief, the submission instructions, and the actual student submission for any WMG assignment. As a result the sheet is completed by several people over time, and is therefore split up into sections explaining who completes what information and when. Yellow highlighted text indicates examples or further explanation of what is requested, and the highlight and instructions should be removed as you populate 'your' section.

This sheet is only to be used for components of assessment worth more than 3 CATS (e.g. for a 15 credit module, weighted more than 20%; or for a 10 credit module, weighted more than 30%).

To be completed by the student(s) prior to final submission:
Your actual submission should be written at the end of this cover sheet file, or attached with the cover sheet at the front if drafted in a separate file, program or application.

Student ID or IDs for group work	**556902**

To be completed (highlighted parts only) by the programme administration after approval and prior to issuing of the assessment; to be consulted by the student(s) so that you know how and when to submit:

Date set	November 2024
Submission date (excluding extensions)	**9 December 2024 by 12 PM (UK time)**
Submission guidance	Tabula link
Marks return date (excluding extensions)	15 January 2025
Late submission policy	If work is submitted late, penalties will be applied at the rate of **5 marks per University working day** after the due date, up to a **maximum of 10 working days** late. After this period the mark for the work will be reduced to 0 (which is the maximum penalty). "Late" means **after the submission deadline time as well as the date** – work submitted after the given time even on the same day is counted as 1 day late.
Resit policy	If you fail this module and/or component, the University allows students to remedy failure (within certain limits). Decisions to authorise resits are made by Exam Boards. These will be issued at specific times of the year, depending on your programme of

	study. More information can be found from your programme office if you are concerned. If this is **already a resit** attempt, this means you will not be eligible for an additional attempt. The University allows as standard a maximum of two attempts on any assessment (i.e. only one resit). Students can only have a third attempt under exceptional circumstances via a Mitigating Circumstances Panel decision.

To be <u>completed</u> by the <u>module leader/tutor</u> prior to approval and issuing of the assessment; to be <u>consulted</u> by the <u>student(s)</u> so that you understand the assignment brief, its context within the module, and any specific criteria and advice from the tutor:

Module title & code	WM9F6-15 - Logistics and Operations Management
Module leader	Mujthaba Ahtamad
Module tutor	Name of the tutor (or put 'see above' if same)
Assessment type	Written Report
Weighting of mark	80%

Word count	3200 words excluding cover page, table of contents, list of references and word in tables and diagrams.
Module learning outcomes (numbered)	1. Analyse the interrelationships and interdependencies between capacity, inventory and delivery performance. 2. Critically evaluate how to manage capacity, inventory and delivery to achieve effective and efficient operational performance. 3. Compare and contrast different tools and techniques for the planning and control of logistics and operations management in order to justify their use in a variety of operational environments. 4. Critically appraise how appropriate technologies can be applied to improve logistics and operations management in a business or sector.
Learning outcomes assessed in this assessment (numbered)	Those tested within this piece of assessment are 1,2 & 4.
Marking guidelines	See Departmental Guidelines available online.

Where to get help: 1. Talk to your module tutor if you don't understand the question or are unsure as to exactly what is required. 2. There are also numerous online courses provided by the University library to help in academic referencing, writing, avoiding plagiarism and a number of other useful resources. https://warwick.ac.uk/services/library/students/your-library-online/ 3. If you have a problem with your wellbeing, it is important that you contact your personal tutor or wellbeing support services https://warwick.ac.uk/services/wss
Assignment brief (please answer both questions)
Question 1 - 1. After selecting a company in the following Sector (Changing Sector), analyse the interrelationships and interdependencies between Capacity, inventory and Scheduling. Then after selecting 1 (either Capacity/Inventory/Scheduling) – critically evaluate how it can be managed to achieve efficient and competitive operational performance in that sector (LO 1 & LO2 – 2000 words - 50 Marks (63%) Question 2 2. In the sector selected (Changing Sector) – identify a real-world issue, and make a recommendation by applying 1 developing technology in which an improvement can be achieved to improve logistics and operations management in that sector. We would like you to appraise the technology critically (LO 4- 1200 words – 30 Marks (37%)

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Interrelationship and Interdependencies

Capacity and Inventory at Toyota motors –

Toyota Motors operates in more than 67 different geographies and 170+ different countries (Gibrilla 2023). In 2023, Toyota Motors produced vehicles slightly more than 11.5 million across the globe (Carlier 2024). To achieve this level of production number, Toyota combines strong interrelationship between Capacity and Inventory. Also, in financial year 2024, Toyota's car sales revenue went up by **7,446.2 billion yen** or 22% from 2023, which made Toyota to reach the mark of **41,266.2 billion yen**. Their operating income also saw a big jump, increasing by **2,440.8 billion yen**, or **111.9%, to 4,621.4 billion yen** (CORPORATION 2024). Such massive operational income displays Toyotas strong hold over its production capacity which directly influences its inventory. Capacity planning at Toyota involves regular forecasts to evaluate production needs, allowing adjustments in workforce levels and equipment usage based on demand. For instance, during low demand, temporary workers are reduced, while demand stability leads to converting them into permanent roles. On the supplier side, Toyota collaborates with vendors to identify weak supply chain links, using dual sourcing and the "Rescue" database to manage supplier capacities and address disruptions quickly (Abdeldayem, Aldulaimi et al. 2023).

These adjustments are enhanced by Toyota Production System (TPS), which focuses on eliminating waste, streamlining operations, and ensuring that every process adds value (Vyas 2011). The JIT system which comes under the umbrella of TPS, aligns production schedule and production capacity with real-time demand, ensuring inventory levels remain lean while minimizing holding costs. The financial report of Toyota 2024 states that Toyota held **4,605,368 million yen** of inventory, also the total cost of products sold is **33,600,612 million yen** (CORPORATION 2024). These number elaborates how closely Toyotas Capacity and Inventory work. Toyota strategically positions inventory to buffer against demand fluctuations, maintains safety stock for disruptions, and leverages precise lead time management to keep production flows smooth. Toyota's inventory and capacity management are closely connected, focusing on efficiency and adaptability. To keep production smooth and avoid excess inventory, Toyota uses strategies like Just-in-Time (JIT) and Heijunka, which ensure steady operations and reduce work-in-progress stock. They also stay flexible by training workers to handle multiple tasks and using machinery that can quickly adapt to different models. With accurate demand forecasting, close collaboration with suppliers, and advanced tools like real-time monitoring and predictive analytics, they balance inventory with capacity needs effectively. Their pull system only starts production when there's actual demand, preventing overproduction and keeping inventory low.

To complement that, Toyota uses Continuous improvement (Kaizen) which boosts efficiency, allowing them to increase capacity while reducing inventory. By synchronizing their supply chain with local suppliers and frequent deliveries, Toyota keeps materials flowing without unnecessary stock. Figure 1 addresses the areas where JIT is being used. Globally, they manage production shifts between plants to match demand and capacity, optimizing inventory across regions. Lessons from the 2011 Tōhoku earthquake led Toyota to stockpile critical parts and refine its systems, making them more resilient. Together, these strategies, driven by TPS and JIT, ensure Toyota achieves operational efficiency while adapting to changing market needs (Shih 2022).

Fig. 1 Just In Time (JIT) (Slack and Brandon-Jones 2018)

Inventory and Scheduling -

Toyota uses a really smart approach to maintain their inventory. It involves mainly 3 key strategies. First, Toyota keeps the right amount of stock in the right location to be ready to tackle any demand changes in future. Second, they maintain extra inventory known as a safety stock in order to face any unexpected disruptions. Finally, Toyota pays close attention lead time and make sure to keep it as low as possible from the supplier end (Shih 2022). In typical production system, processes often rely on Work in Process (WIP) inventory to handle the disruptions and demand damages. Although, this approach aims to keep production schedules running smoothly, it can lead to stock imbalances between processes and can result in dead stock. To tackle these issues, Toyota developed the Just-In-Time (JIT) production system. JIT minimizes lead time by ensuring that each process produces only the parts needed at the exact time they are required, while maintaining the minimum inventory necessary to connect the processes. This approach not only prevents inventory imbalances but also highlights inefficiencies, such as surplus equipment or unused workforce. (Lewis and Slack 2003). This approach of inventory management helps Toyota at Scheduling the production. For example, at a Toyota plant making injection-molded parts, workers improved efficiency by cutting the time to change a large molding die from five minutes to three. This allowed the company to reduce batch sizes by 40%, moving closer to their goal of producing one part at a time. However, Toyota sometimes prioritizes certain goals over others, like temporarily keeping more inventory or using larger batch sizes than usual for a just-in-time system (Bowen 1999).

Heijunka, a Japanese word which means “leveling” plays vital role in integrating inventory and scheduling at Toyota which comes under the branch of TPS. Fig. 2 “Heijunka” shows three operational benefits. Heijunka breaks down total order volume for a given planning period into smaller scheduling intervals which helps Toyota to maintain steady production rate and minimize inventory fluctuations (Soliman 2023). Heijunka establishes a recurring production pattern for each scheduled period, determining the mix of vehicle on a specific assembly line. A stability in inventory management can be achieved by this approach, since Heijunka can also be used for predictability. This approach helps Toyota Production System to manufacture diverse models in a single batch, aligning with inventory with fluctuating consumer demand (magazine 2013). Toyota’s production scheduling team follows the control of purchasing team over how materials are provided, based on customer demand. Takt time represents the rate at which customers buy products and aligning production with this rate helps Toyota to reduce the waste and maintain the accurate quantity of inventory which improves the efficiency and productivity of the company (Labs 2024). Also, Heijunka facilitates JIT by aligning inventory arrivals with production needs. This approach reduces work-in-progress inventory as well as stock on hands. Also, Toyota has revised its 2024 global production forecast to 9.8 million units, a 5% reduction from the previously planned 10.3 million, due to output suspensions at its domestic factories in Japan. This has happened first time in past 4 years that the annual production is expected to drop compared to the last year (Thompson 2024). This reduction might lead to major adjustments in Toyotas production scheduling across its factories. Also, this might lead to tighter inventory levels especially for high demand car models. Lowered inventory levels might create some scheduling disruptions. However, if Toyota aligns its production scheduling with current market conditions and them shorten inventory level they might avoid overproduction and operational disruptions.

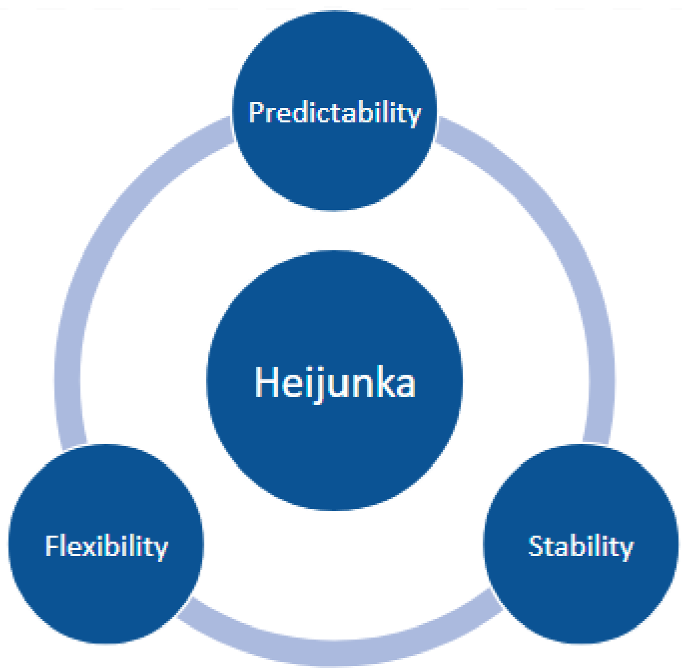

Fig.2. Heijunka (Kanban Tool).

Capacity and Scheduling –

Toyota has always been dominating the auto sector. As discussed earlier, Toyota operates 67 manufacturing facilities and globally and markets its vehicles in more than 170 countries with a strong workforce of 370,000 (UK). This global presence allows Toyota to strategically align capacity and production scheduling across different regions. By taking the advantage of its wide supplier network, Toyota maintains its inventory which helps for planning its capacity and schedule the production.

Toyota's capacity planning and production scheduling work closely together and are central to the Toyota Production System (TPS). Capacity planning follows the Just-in-Time (JIT) principle, ensuring that production aligns perfectly with customer demand. This minimizes excess inventory and prevents shortages by producing only what is needed, when it is needed, and in the right quantities (Htun, Maw et al. 2019). Toyota's lean manufacturing practices, which focus on eliminating waste and streamlining workflows, further support efficient production scheduling.

To optimize this process, Toyota uses Heijunka. A production leveling method that balances capacity and avoids overburdening resources, ensuring a steady workflow even during fluctuating demand (Boutbagha and El Abbadi 2022). Additionally, the company employs a pull system, which ties production scheduling directly to actual customer orders rather than forecasts, reducing overproduction and ensuring capacity is used efficiently. Continuous improvement, or kaizen, further strengthens the link between capacity planning and scheduling by addressing bottlenecks and improving processes over time. This integration enables Toyota to operate efficiently, reduce waste, and respond effectively to customer needs (Lander and Liker 2007). Recently 'The Japan Times' stated that, Toyota's decision to reduce maximum operating hours by 30 minutes per day in its Japanese plants will impact its production schedule and capacity. By shortening overtime, Toyota will adjust production schedules to complete tasks within the revised hours, likely spreading work more efficiently across shifts. This change is designed to improve product quality and ease pressure on workers, which could help avoid issues like recent certification scandals. However, Toyota will reduce its daily domestic production from 15,000 to 14,000 vehicles to align with the shorter hours, slightly lowering its domestic capacity. Despite this, the company plans to meet its global target of producing 10.3 million vehicles by relying more on overseas operations. This approach also reduces strain on suppliers, promoting a more sustainable and reliable production process overall (Times 2024).

Fig. 3 Production Scheduling (Times 2024)

Overall, Toyota's capacity, inventory and scheduling are interdependent and interrelated to each other under the umbrella of Toyota Production System (TPS). The company's Just-In-Time approach ensures production aligns with costumer demand, minimizing excess inventory while preventing shortages. Heijunka, a leveling balances capacity and maintains a steady workflow, supporting efficient inventory management and scheduling.

Toyota Motors Inventory Management -

Toyota's inventory management is based on the Toyota Production System (TPS), which focuses on reducing waste and making production more efficient. They use strategies like Just-In-Time (JIT) production and the Kanban system. JIT means materials and parts are only delivered when they're needed, which helps save on storage costs, lowers inventory levels, and improves cash flow. While JIT significantly reduces waste and costs, it relies heavily on accurate demand forecasting and timely supplier deliveries. Any disruptions in the supply chain can lead to production delays. JIT Production ensures only what is needed, when it is needed and how much it is needed, which certainly helps to reduce unnecessary or excess inventory and prevents the production of goods which is not required. (Htun, Maw et al. 2019).

Example of Toyota's Inventory Management Technique – The Case of JC 8037 Cylindrical Bearing – (Nistane and Srinivas Viswanath 2013)**.**

As mentioned, TPS manages inventory using the JIT and Kanban system to optimize their manufacturing and efficient usage of inventory. An excellent example of this statement is the part named JC 8037 a Cylindrical Bearing, which faced challenges due to inefficiencies and push-based production system. The primary issue occurred during production was, consistently increase in Work in Progress Inventory (WIP) for the cylindrical bearing which already exceeded company's targeted level of 6 days. This problem arrived from a forecast based push-system where parts were manufactured without aligning production with real time demand expectations. As a result, surplus inventory accumulated at various stages of production leading to higher production cost and longer production cycle. Additionally, this misalignment resulted in frequent machine idle time. To overcome these issues Toyota integrated their Just in Time technology with Kanban system. The Kanban system operates on the principle of producing components only required by subsequent stage. Thus, converting the process into demand driven "pull system". For example, the final stage of manufacturing process, track grinding it analyses the production time taken by machine and worker on a component in order to reduce the work in progress inventory and smooth flow of tasks from beginning to the finish. This reduces the bottlenecks and maintains inventory balances throughout the manufacturing line. The implementation of combination of these two systems led to a significant improvement. WIP inventory for the JC 8037 outer ring was reduced by 15% whereas the inner ring saw a decrease of 12%. Similar results were observed for other cylindrical bearing types with almost 15% reduction in WIP inventory for JC 8038/33B. Furthermore, the machine idle times were significantly reduced with 7.1 % percent improvement were seen for idle time of outer ring and

6.5% for inner ring. This synchronization reduced the bottleneck and maintained inventory balance and lowered idle time throughout the manufacturing line.

Toyotas inventory holding cost in 2023 was **4,255,614 million yens** and it went up by approximately 8.22% which made it reach **4,605,368 million yens**. This rise in inventor cost ensures Toyota can better manage the supply chain disruptions which may occur in future and also to meet the uncertain market demand and to maintain consistence production levels during industry challenges. (CORPORATION 2024).

However, the COVID-19 pandemic showed some weaknesses in this system. Global supply chain disruptions, factory closures, and shipping delays caused shortages of important parts, like semiconductors, which stopped production and delayed deliveries. Demand became unpredictable, even car sales dropped during lockdowns but spiked when restrictions were taken off. The COVID-19 pandemic revealed weaknesses in Toyota's usually strong inventory management system. Dealer inventories ran out almost immediately, showing the limits of their just-in-time (JIT) approach. Even though Toyota kept about 45 days of stock as a backup, which was once thought to be enough for emergencies, it wasn't enough to handle the massive disruptions caused by the pandemic (Dive 2023). This experience made it clear that Toyota's inventory strategy, once seen as the best in the industry, needed improvement. The company is now rethinking its approach to focus more on building a stronger, more resilient supply chain to prepare for future challenges. Also, JIT is mainly focused on getting right things on right time but the drawback of this approach is when there's a sudden spike in demand which cannot be predicted earlier can make Toyota short of inventories when they are actually required.

To improve, they should work with suppliers in more regions and have backup suppliers to handle global issues better. Creating stronger plans for risks, like alternate shipping routes and emergency stock, would help them prepare for crises. Toyota could also keep slightly larger backup inventories of important parts to avoid production stops. Using digital tools and blockchain could improve communication and transparency with suppliers (Choi 2022). Also, using a buffer can safeguard JIT processes from disruptions in upstream supply chains. For instance, maintaining a stockpile of components in a warehouse or having a flexible facility capable of producing components can help support downstream JIT operations during interruptions. Toyota could consider using a hybrid system that combines the Just-In-Time (JIT) method with a small amount of safety stock to make their operations more reliable during disruptions. They can also make their inventory system more flexible by moving stock to different locations or channels based on where it's needed most. Additionally, working closely with suppliers through programs like vendor-managed inventory (VMI) could help reduce costs, as suppliers would take responsibility for monitoring and replenishing inventory levels. This way, Toyota can stay efficient while also being better prepared for unexpected challenges (Ugrinov, Ćoćkalo et al. 2024).

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The semiconductor shortage has caused major problems for supply chains, especially in the automotive industry. One big reason for this issue is the sudden increase in demand during the COVID-19 pandemic, as more people bought electronics like phones and laptops, which use semiconductors. This demand was higher than what manufacturers could handle since they were already working at full capacity before the pandemic. Many car companies also used a "just-in-time" strategy, where they ordered parts only when needed to save money on storage. When car sales dropped in 2020, these companies reduced their orders for semiconductors, but when sales picked up again, they didn't have enough chips, causing delays and even production shutdowns. Making semiconductors takes a long time, over four months for production and more than three years to build new factories, so catching up on demand isn't easy. On top of that, issues like power outages, natural disasters, and conflicts like the Russia-Ukraine war have made things worse. For example, Ukraine supplies neon gas needed for making semiconductors, and Russia provides palladium, which is another important material for semiconductor. Companies have also started placing random, high-priced orders, which creates even more confusion and doesn't solve the problem because of the long production times. These challenges combined have deeply disrupted the supply of semiconductors, slowing down car production and impacting other industries that rely on these essential parts (Ondrej Burkacky, Deichmann et al. 2022).

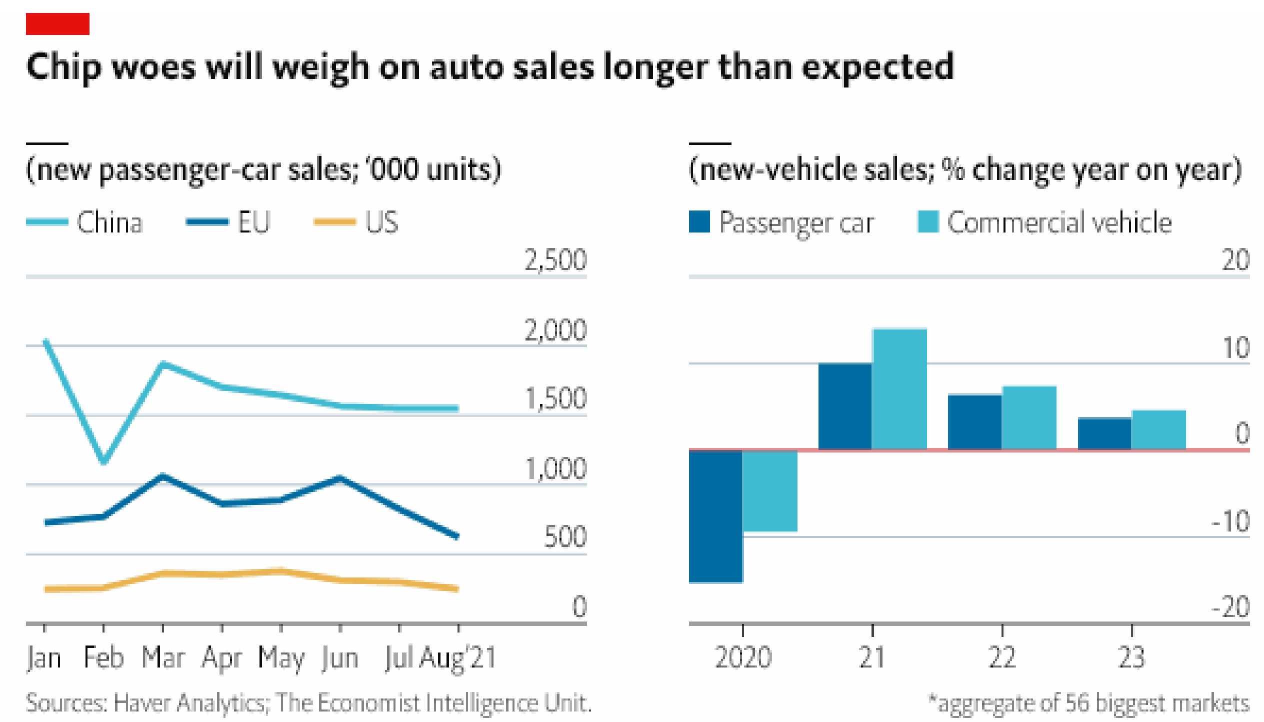

Fig. 4 Semiconductor Shortage Effect on Auto Industry (Intelligence 2021).

3D printing could be the answer for the problem of supply chain disruptions occurred due to semiconductor shortage. This technology allows factories to quickly create parts layer by layer, right when they're needed, instead of waiting weeks for new chips to arrive. It can also combine multiple parts into one, reducing the number of components that need to be ordered. This makes supply chains simpler and stronger. Although there are still challenges, like keeping production areas really clean, experts believe 3D printing could make a huge difference for car manufacturers dealing with chip shortages (Griffiths 2021).

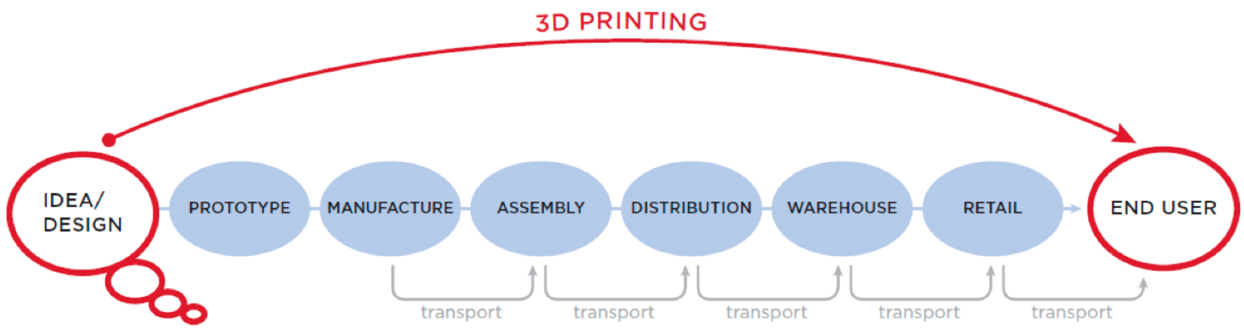

Fig. 5. How 3D Printing Can help Auto sector (Özceylan, Çetinkaya et al. 2017)

1. Digital Inventories combined with 3D printing allow parts to be manufactured on demand locally, reducing reliance on global supply chains and semi-conductor component.
2. This approach minimizes the need of physical inventories which helps to reduce storage cost and lead times.
3. Localized 3D printing production improves resilience against supply chain disruptions especially geopolitical and environmental areas.
4. 3D printing can consolidate multiple parts into single unit, potentially reducing the total number of components required and simplifies supply chain.
5. The technology allows for faster production of essential parts when actually needed, also helps enabling quicker adaption to changing demand.
6. It also helps to reduce environmental impact by reducing the transportation part which directly help manufacturers to reduce logistic efforts (Molitch-Hou 2024).

General Motors ran into a last-minute issue when they decided to add a "spoiler closeout seal" to the 2022 Chevrolet Tahoe. They needed this part for 30,000 vehicles, but traditional methods like injection molding would take too long to make the 60,000 seals required. To fix the problem, GM turned to 3D printing. They worked with GKN Additive, which used HP Multi Jet Fusion 3D printers to quickly produce and finish all 60,000 seals in just five weeks. This fast solution helped GM avoid delivery delays and keep production on track. (McEachern 2022).

Semiconductor manufacturing relies on highly specialized machines, and 3D printing can optimize the production and performance of these machines in different ways:

1. **Rapid Prototyping** - 3D printing helps car manufacturers quickly create and test new semiconductor parts. This makes the design process faster, allowing companies to bring products to market in less time. For example, instead of taking weeks to make a prototype, 3D printing can do it in just a few days, which is very helpful during chip shortages.
2. **On-Demand Production** - With 3D printing, companies can make semiconductor parts only when they need them. This reduces the need for storing large amounts of inventory and helps manufacturers quickly adapt to changes in demand or supply chain issues.
3. **Creating Complex Designs** - 3D printing can produce detailed and intricate parts that are hard to make using traditional methods. These advanced designs can improve the efficiency of semiconductor parts and reduce waste during manufacturing.
4. **Local Production** - Using 3D printing, car companies can set up production facilities closer to their factories. This reduces their dependence on overseas suppliers and avoids delays caused by shipping or global issues like political conflicts.
5. **Requirement of new material for better chips** - 3D printing allows the use of innovative materials that could make semiconductor parts better and cheaper. For example, materials like conductive polymers might perform better or cost less than the silicon used in most chips today. (Chakraborty 2016).

3D printing can also help manage semiconductor shortages in the auto sector by streamlining logistics. Localized production reduces reliance on global supply chains, cutting transportation delays and costs. On-demand manufacturing lowers storage needs, while creating complex parts in one step reduces shipments. This ensures steady production and efficient supply chain management.

1. **Reduced Transportation Needs** – By enabling local production on semiconductor by 3D printing, auto makers would be able to minimize the transportation of part from supplier to their manufacturing plant. This approach would also help in cost saving and cutting down Transportation time. This also reduces the risk of damaging of parts and uncertain delivery time.
2. **Decreased Lead Time** – With the ability to produce the part on demand, companies can drastically reduce the lead time associated with sourcing of semiconductors and their shipment. This flexibility allows manufacturers to adapt the uncertain or sudden change in demand or any supply chain disruption occurred.

3. **Sustainability and waste reduction** – By producing what is needed and when is needed, automakers can minimize excess inventory. 3D printing will help automakers in a sustainable way as well, by lowering the unnecessary transportation and logistical involvement which help in reducing the emissions and waste generated which ultimately lowers the costs associated with waste disposal and excess production (Campbell, Williams et al. 2011).

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