Micron NUS-ISE Business Analytics Case Competition 2023

Team Coco Nutnut's Final Report

Proposal 1: Build a New Building Connecting to the Existing One.

Choosing to build a new building connected to the existing one has its pros and cons. There are several advantages to taking up proposal 1. Having a newly connected building allows for expansion of the current infrastructure, creating more space for operations to be done within the same area. Due to closer proximity between the two buildings, operations can run more smoothly and efficiently. Equipment required to produce more semiconductors can be shared across the buildings, and information between departments can easily be conveyed across. Take for example, hypothetically, if there were two large documents that required 10 minutes to be printed, and there is only 1 printer in each building, if the two buildings were connected, it is possible to print both documents concurrently, in 10 minutes. This saves time and increases the efficiency of work done. In addition to this, new facilities built in the new building can be enjoyed by those working in the old building, and vice versa. Newly built meeting rooms, canteens, lounges etc. can be used by employees from the old building. As such, the construction of the new building can be seen as an upgrade to the working environment of current employees. This translates to an increase in morale of the employees, potentially boosting productivity[1].

Additionally, by expanding its existing building, Micron can attract more talents to join the company. These talented individuals are more inclined to join a company with a better working environment, a newer office and a chance of networking with other professionals[2]. This can potentially give rise to more income generating ideas, as well as increase efficiency hence productivity for Micron. Adopting proposal 1 also allows Micron to save on expenses. With the increased production of semiconductors in the same area, Micron can ship in raw materials required, as well as ship out the finished products in

[1] Better Work (2015). *Working Conditions, Productivity and Profitability Evidence from Better Work Vietnam.* Retrieved February 19, 2023, from https://betterwork.org/wp-content/uploads/2017/04/ILO-1513-Research-Brief-for-DP-No.-17-Are-Sweatshops-Profit-Maximizing.pdf

[2] Mondelez International (2021, March 1). *The Benefits of Working in a Large Company.* Retrieved February 19, 2023 from https://www.mondelezinternational.com/News/6-Benefits-of-Working-in-a-Large-Company#:~:text=A%20larger%20company%20means%20a,your%20professional%20and%20personal%20development.

bulk. This reduces shipping costs for Micron[3]. If there were to be damages within the two buildings, Micron can hire a single company to help fix these damages, which will save on repair expenses due to second-degree price discrimination. Most companies will be willing to lower the unit cost of repair if the customer is willing to employ them for a large volume of services. The concept of second-degree price discrimination applies to many different services, including renovation, repair and maintenance[4]. As such, Micron will be able to reduce its expenses in these areas.

However, adopting proposal 1 can have its own set of problems. Having a newly connected building serves the risk of losing production given an unforeseen circumstance. For instance, if there was a power outage in the general vicinity of Micron's building, both buildings would become unavailable to produce any supply of semiconductors. Production would be halted, and employees become less efficient during this period[5]. Another issue that will arise would be the negative impacts due to construction. As the new building is to be constructed beside the existing one, there will be excess noise and dust generated. In general, construction will create a less than ideal working environment for many, given that the area is now dustier and louder. Employees may lose morale or work less efficiently due to the construction, giving rise to lower productivity for the company. There is also the possibility of more employees falling sick, due to the excess debris floating around, triggering allergies and increasing the risk of irritation to the eyes, nose, skin and throat[6]. As such, during the construction period, Micron may observe a period of lower productivity, as compared to the years before the construction.

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[3] All Day Chic. *Why Buying in Bulk is a Huge Benefit For Your Business.* Retrieved February 19, 2023, from https://alldaychic.com/buy-in-bulk-benefit-for-business/

[4] Corporate Finance Institute Team (2022, November 28). *Price Discrimination: A pricing strategy that charges consumers different prices for the identical good or service.* Retrieved February 19, 2023, from https://corporatefinanceinstitute.com/resources/management/price-discrimination/

[5] Fakih, A., Ghazalian, P. and Ghazzawi, N. (2020, December 3). *The Effects of Power Outages on the Performance of Manufacturing Firms in the MENA Region.* Retrieved February 19, 2023, from https://www.degruyter.com/document/doi/10.1515/rmeef-2020-0011/html?lang=en

[6] Halevy, J. *Construction Sites are a Source of Sickness.* Retrieved February 19, 2023, from https://www.vietnammedicalpractice.com/hanoi/en/news/construction-sites-are-source-sickness

Next, a potential setback that Micron may face due to the choice of adopting proposal 1 is the increase in population density in the area around the building. The severity of this setback depends mostly on the current location of the existing building. Due to the construction of the new building, it is expected that Micron will employ more individuals to be involved in more operations, fully utilizing its newly built facility. Naturally, this leads to more people commuting to the area every day, increasing traffic. If the existing building is located near or within a central business district, there will be an increase in frequency of traffic jams, leading to employees reaching office late. The accumulated time spent waiting in the jam could have been used more productively[7]. On top of this, higher population density gives rise to the spread of diseases, potentially creating an outbreak of infectious diseases within the vicinity of the building, or within Micron's buildings itself. This will lead to lower productivity due to more employees being unfit for work.

The location of the existing building plays a part in determining whether proposal 1 is the right choice for Micron as it affects the cost of expansion. If the existing building is built on prime land, the cost of expansion would be extremely high. On the contrary, if the building is built on relatively cheaper grounds, choosing proposal 1 can be seen as beneficial due to the lower cost of expansion and construction. In addition, adopting proposal 1 may backfire if the laws of the country that the existing building is in disfavours Micron. For instance, if the corporate income tax and goods and services tax rates are high in the country, increasing production in the same country is unwise. A large percentage of the additional profits from utilizing the new resources are paid to the government in the form of taxes, instead of being distributed to shareholders or kept as retained earnings. However, the converse is true. If the tax rate of the country is low, Micron will benefit. In addition, if the government of a country is trying to attract Multinational corporations, such as Micron, there may be additional grants and funding from the government. If Micron's building is located in such a country, it is definitely advantageous to expand its current building. To conclude, whether it is economically

[7] Somuyiwa, A. O., Fadare, S. O., Ayantoyinbo, B. B. (2015, September). *Analysis of the Cost of Traffic Congestion on Worker's Productivity in a Mega City of a Developing Economy.* Retrieved February 19, 2023, from https://www.irmbrjournal.com/papers/1438578538.pdf

viable to construct a new building connected to the existing one will depend on the building’s current location.

Proposal 2: Build a New Independent Building.

Building a new independent building for Micron under Proposal 2 has both advantages and disadvantages. The ability to customize the design and layout of the building to meet Micron's specific needs would be a plus. This includes optimizing floor space, designing production line layouts, and incorporating high-tech equipment and systems tailored to their operations. An example of a company that has used customization to its advantage is Intel. The company announced plans for a new semiconductor fabrication plant in Oregon. The plant was built to be highly customized, with an emphasis on optimizing floor space, incorporating advanced technologies, and minimizing energy consumption. To develop next-generation silicon process technologies, Intel engineers now have an additional 270,000 square feet of clean-room space[8]. In the case of Micron, constructing a new independent building would allow them to maximize their efficiency and output. They can design specialized clean rooms to prevent contamination and incorporate advanced automation and robotics technology to increase production efficiency. The design of the building itself can also be customized. Micron may also opt to create a building that embodies its brand values and vision, resulting in an environment that is not just practical but also inspiring for employees and visitors. This can help to reinforce the company's culture and values[9], fostering employee pride and loyalty. By allowing Micron to design a space that is tailored to their specific needs and requirements, it improves efficiency, productivity, and output. Customization is thus a powerful advantage of building a new independent building and should be considered for Micron.

Another advantage of constructing a new independent structure is the ability to expand. When a company constructs a new building, they have the option of designing it to accommodate future growth and expansion. This means that as demand for their products or services grows, the company can increase production capacity without disrupting current operations. Samsung is one example of a company that has benefited

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[8] Takahashi, D. (2022, April 11). *Intel opens $3B factory expansion in Oregon*. VentureBeat. Retrieved February 19, 2023, from https://venturebeat.com/business/intel-opens-3b-factory-expansion-in-oregon/

[9] Brutvan, C. (2021, October 22). *A case study: The role of design in corporate culture*. Clark Nexsen. Retrieved February 19, 2023, from https://www.clarknexsen.com/blog-role-of-design-corporate-culture/

from expansion. The company announced plans to construct a new semiconductor fabrication plant in Texas[10]. The plant was designed to accommodate future growth and expansion, allowing Samsung to increase production capacity without disrupting existing operations. Samsung could ensure that they had enough space and resources to support potential development by constructing a new independent plant. The new factory will increase manufacturing of high-tech semiconductors for 5G mobile communications, advanced computing, and artificial intelligence, as well as improve supply chain resilience[11]. This demonstrates that expansion is a significant advantage in industries that are rapidly evolving or where product demand is unpredictable. For example, in the technology industry which Micron is in, product demand can fluctuate quickly due to factors such as changing consumer preferences or new product innovations[12]. With data being the new currency[13], Micron can respond quickly to changes in demand and stay ahead of the competition by constructing a new independent building that is designed for expansion. Overall, the ability to expand is a significant benefit of constructing a new independent structure. It enables Micron to create a space that is scalable and adaptable to changing market conditions, thereby ensuring long-term growth and success.

However, there are also some cons to Micron adopting proposal 2, the cost. When deciding whether to build a new independent building or expand an existing building, cost is an important factor to consider. The cost of acquiring land, designing and constructing the building, and equipping it with equipment and systems all contribute to the initial cost of constructing a new independent building. Land acquisition is a significant cost

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[10] Shead, S. (2021, November 24). *Samsung plans to build a $17 billion chip plant in Texas*. CNBC. Retrieved February 19, 2023, from https://www.cnbc.com/2021/11/24/samsung-announces-17-billion-chip-plant-in-texas.html

[11] Guardian News and Media. (2021, November 24). *Samsung to build $17bn semiconductor factory in Texas*. The Guardian. Retrieved February 19, 2023, from https://www.theguardian.com/technology/2021/nov/24/samsung-to-build-a-17bn-semiconductor-factory-in-texas-us-chip-shortage

[12] *The new rules for bringing innovations to market*. Harvard Business Review. (2014, August 1). Retrieved February 19, 2023, from https://hbr.org/2004/03/the-new-rules-for-bringing-innovations-to-market

[13] *Episode 4: Data is the new currency*. CIO. (2022, November 21). Retrieved February 19, 2023, from https://www.cio.com/article/412894/episode-4-data-is-the-new-currency.html#:~:text=Data%20is%20the%20new%20currency%20of%20business.,effectively%2C%20win%20in%20the%20market.

associated with the construction of a new independent building. Choosing the right location for a new building can be a time-consuming and costly process, especially in densely populated areas or areas where real estate is in high demand[14]. Additionally, building a new independent structure may demand extra infrastructure investments, such as utility line construction or road access to the site. Another thing to consider is the cost of planning and developing the new building. Creating a new separate structure allows for more customisation, but it also complicates and lengthens the engineering and design process. This may result in higher design and engineering fees for Micron, as well as potential construction delays during construction. Because a new independent building is built from scratch, construction costs can be higher. This can entail significant material, labour, and equipment costs, in addition to possible delays due to weather or other unforeseen circumstances. Proposal 1, expanding an existing building, on the other hand, may be less expensive because it can be done by adding on to an existing structure. Because some of these costs may have already been incurred during the original construction process, it can reduce the cost of land acquisition, design, engineering, and construction. A building expansion may also need less investment in new infrastructure, such as electrical lines and road networks[15]. One of the most essential issues is the cost of constructing a new independent building or extending an existing structure. Constructing a new independent building can provide benefits such as customisation and extension possibilities, but it may be more expensive in the beginning than expanding an existing structure.

While Proposal 2, which includes the construction of an independent building, may have certain advantages over Proposal 1 in terms of improved flexibility and customisation, it may also have some disadvantages, such as lengthier construction delays. Compared to expanding an existing building, building a new independent building requires more construction work. Building erection, foundation work, and utilities and infrastructure

[14] *The geography of demand for residential and commercial space*. Centre for Cities. (2018, April 3). Retrieved February 19, 2023, from https://www.centreforcities.org/reader/city-space-race-balancing-need-homes-offices-cities/geography-demand-residential-commercial-space/

[15] Sunol, H. (n.d.). *Choosing a warehouse location: 7 critical criteria to consider*. Warehouse Technology Articles. Retrieved February 19, 2023, from https://articles.cyzerg.com/choosing-a-warehouse-location-7-critical-criteria-to-consider

installation are all part of the construction process. A construction project can take a lot of time, and the timeline for construction may be affected by factors such as weather conditions, labour availability, and unforeseen issues. In addition, obtaining permits and approvals from local authorities is another time-consuming aspect[16] of building a new independent building. Depending on the zoning code, building code, environmental regulations, and other factors, certain requirements may need to be met. Obtaining these permits and approvals can be a complex and lengthy process, and delays in the approval process can further extend the construction timeline. In contrast, since existing buildings and infrastructure are already operational, the first proposal may require less extensive construction work and less permits and approvals. Overall, this helps to reduce construction time and reduce the likelihood of delays.

[16] *Structural plans and permit approvals*. BCA Corp. (n.d.). Retrieved February 19, 2023, from https://www1.bca.gov.sg/regulatory-info/building-control/structural-plans-and-permit-approvals

Analysis of Q2a

Introduction

Using the information provided by the question, we derived an algorithm with self-imposed rules as to how the operations will take place.

Firstly, it is noted that all Lots undergo Step 2 in Building X and all Lots undergo Step 4 in Building Y. Thus considering transportation, Lots awaiting Step 2 in Building Y are given highest priority in transportation to Building X and Lots awaiting Step 4 in Building X are given highest priority in transportation to Building Y. To fill the remaining space on the Truck, for transportation from Building X to Y, Lots awaiting Step 3 are given priority followed by Lots awaiting Step 1. For transportation from Building Y to X, Lots awaiting Step 5 are given priority followed by Lots awaiting Step 6. If there still exists space on the Truck, it is ignored and the Truck is sent off, so as to utilise the Truck as much as possible.

Secondly, priority was also given in Workstation Groups for which process it should carry out based on what we believed would generate the most output. In Workstation A, Step 3 was given priority followed by Step 1. In Workstation B, Step 6 was given priority followed by Step 2. In Workstation C, Step 5 was given priority followed by Step 2. In Workstation D, Step 4 was given priority followed by Step 1. In Workstation E, Step 5 was given priority followed by Step 3 followed by Step 1. In Workstation F, Step 6 was given priority followed by Step 4.

Approach

For the program, we chose to write it out in Java using Object-Oriented Programming to help model the Buildings, Workstations, Truck, and Lots. Using the algorithm as described above, the following program was constructed.

To begin with, an Immutable List object class was used throughout the program as a form of List object. An Immutable List is an Array List which restricts changing its contents after creation. The only way to ‘update’ an Immutable List is to create a new Immutable List

with the original contents and then adding or removing the new elements. We decided to use the Immutable List as it adheres to the principles of effect-free programming.

A Lot object was created which consisted of a unique ID number which we used for tracking and an int indicator to determine the latest Step the Lot has undergone. The indicator has values of 0, 1, 2, 3, 4, 5, 6, 0 indicating that the Lot has not undergone any step.

A Building was given an inventory which was made of 7 Immutable Lists, one for each type of Lot, determined by the stage of production it has gone through. A method was given for adding a Lot to the Building's inventory and another method was given to remove a Lot of specified type from the Building's inventory.

A Workstation Group was modelled as a Machine. A Machine was given an ID number, a time value to indicate when it is next available for use and an one Lot inventory which holds the Lot which is undergoing the process within the Machine. When the Machine is not being used, a placeholder Lot of ID 0 was used to fill its inventory. A Machine also has a method to update the next available time for the Machine based on the process it is set to carry out.

The Truck was given an Immutable List inventory capable of holding up to 5 Lots. It also has a time value which indicated when it is next at a Building and a location indicating the next Building it will be at, according to its time attribute. The location was given a value of 1 for Building X and a value of 2 for Building Y. Additionally, a method called 'move' was given to Truck to provide it with a new inventory for transport and update its location and time.

Finally, everything took place in a Main Java file. The two Buildings X and Y, Truck, Machines were constructed. Lots awaiting to undergo Step 1 were constructed on demand. A while loop was utilised to simulate the operations from a given time of 0 minutes up to 10080 minutes or a week of continual operation. Every 5 minutes, the Truck

is checked for its location and time. If the Truck is present at any Building, it is loaded with new inventory and sent off after updating its time and location. Next, the Machines in each building are checked one by one. If a Machine is idle, it is directed to carry out a Step based on the priority previously established if the Building the Machine is in has inventory of a Lot awaiting that Step. If there is no Lots in the Building's inventory waiting for any of the Steps that can be carried out by the Machine, it is left idle. At the end of every 5-minute loop, the time, the unique ID of the Lot in each Machine if there exists one, the IDs of the inventory of the Truck and its destination is recorded. The final output is the list of recordings and the final number of Lots that were processed throughout the week of operations.

Outcome

Running the program with the specified timing of a week, it resulted in a maximum throughput of 791 finished Lots. It is estimated that a Lot takes on average 62.5 minutes to undergo the production process from start to finish.

For a total of 60480 possible Workstation Group minutes for 6 Workstation Groups operating constantly for a week, it is estimated that to create 791 finished Lots, 49437.5 Machine minutes were used. This would result in an overall Machine usage efficiency of 81.7%, rounded to 3 significant figures.

Analysis of Q2b

Using the data obtained in Q2a, we constructed a dashboard in PowerBI using 5 performance metrics to monitor the production line. These metrics, which are measured in weeks, include:

1. Production Volume (Units produced per Week)
2. Total Time Spent on Transportation (Hours spent travelling per Week)
3. Truck Slot Utilisation (Slot Uptime vs Downtime per Week)
4. Workstation Utilisation (Workstation Uptime vs Downtime per Week)
5. Total Production Time per Building (Production Hours in Building X vs Y per Week)

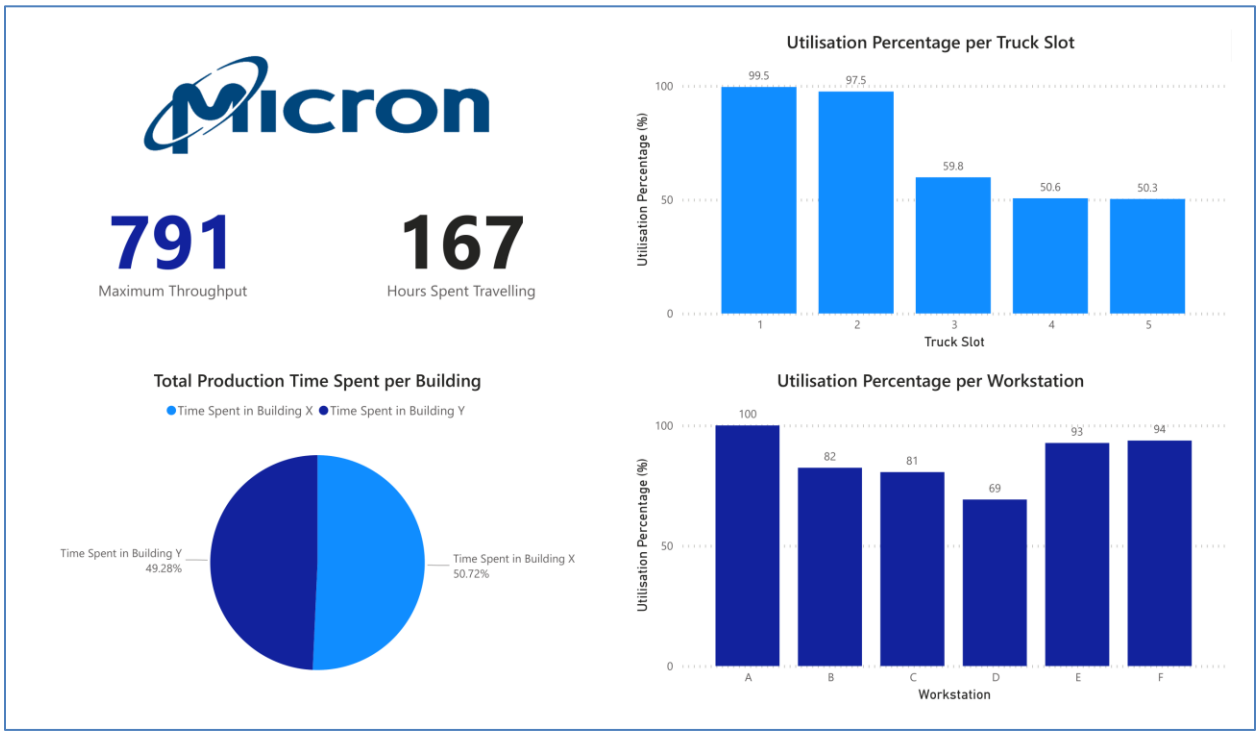

Image 1: Coco Nutnut's Dashboard

Apart from Production Volume which is directly related to production line performance, our metrics which focus on quantifying the utilisation of resources. This allows us to assess if resources are being used to their full potential, and pinpoints underutilised resources so that we know exactly where to optimise the allocation of our resources.

1. Production Volume

By knowing the maximum possible Production Volume, we can make more informed decisions with regards to resource allocation. This will enable greater revenue maximisation and help us predict stock availability for sales. For clarity, this value is displayed as a single number.

2. Total Time Spent on Transportation

By knowing how much time is spent travelling per week, we are able to quantify and calculate its associated opportunity costs. This includes time that could have been used for producing more units, or petrol and vehicle maintenance money which could otherwise be saved to increase overall profit. For clarity, this value is displayed as a single number.

3. Truck Slot Utilisation

Knowing each truck slot's utilisation percentage gives insight on the usage frequency of each slot when executing the optimal production strategy. In this case, we see that only 2 of 5 truck slots are gainfully used. Since the truck is underutilised, perhaps the company can use a smaller vehicle which moves faster than a truck and consumes less petrol. A faster vehicle will lead to greater efficiency in the production line, and lower petrol consumption will increase profits. We used a bar chart to present this information as it allowed clear comparison between the various truck slots to show the difference in utility.

4. Workstation Utilisation

Knowing each workstation's utilisation percentage gives insight on the usage frequency of each workstation when executing the optimal production strategy. In this case, most workstations have high utilisation percentage, suggesting low downtime which means great efficiency. However, Workstation D is relatively under-utilized. It may be wise to readjust the steps which Workstation D can handle, such that it is not underutilised. For example, since Building Y lacks a workstation that handles Step 2, Workstation D can take on that role. Likewise, we chose a bar chart to represent this information as it gives an overview of how each workstation is being utilized relative to their counterparts.

5. Total Time Lots Spend in Each Building

Knowing the distribution of total time lots spend in each building helps us assess the utility of having a secondary building. In this case, since both buildings are equally utilised for production, having a second building seems to be a reasonable investment as it actively contributes to the efficiency of the production line.

Conclusion

Based on our analysis in Questions 1 and 2, our team of Planning Engineers have concluded that in order to strategically increase Micron's production capabilities, we should adopt Proposal 2 and build a new independent building beside the original building to improve the production line's efficiency. However, more optimisation can be done with regards to the transportation of lots from one building to another and the allocation of jobs to workstations (Workstation D in particular).