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Factory Location Recommendation for Haldon

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Table of Contents

Executive Summary

This report provides an analysis and evaluation of all the factors that will determine which of the 3 proposed countries, Australia, Canada and Indonesia will be selected as the location for Haldon to set up a new car manufacturing factory. The factors that have been considered are Net Present Value (NPV), Demand, Environmental Impact, Worker's Quality of Life, Reliability and Quality of vehicle. The main method of analysis is the Decision-Making Framework that follows a series of phases such as framing, modelling and assessing. The modelling phase in particular that involves the use of a payoff matrix will be the primary tool in selecting the car manufacturing factory location. The supplementary method includes using linear optimisation on Matlab to calculate both the Net Present Value and projected maximum profits for each factory location. All calculations can be found in the appendices. Findings show that Indonesia has the highest project maximum profits and as a result, the net present value for Indonesia will also be the highest. In addition, Canada has the highest demand in comparison to Australia and Indonesia. In terms of environmental impact, Canada's factory has the best total environmental impact (TEI) scores meaning it has the least amount of pollutants that include CO_2 emissions, NO_x emissions and water used from producing vehicles. In terms of Worker's Quality of Life, a combined performance on job creation, union membership, freedom index, human rights index and global rights index shows that Canada has by far the best ethics for workers and individuals alike. Moving on to the reliability and quality of the vehicle, findings show that Australia has the best normalised average failure rate (NAF). The reports find that the final recommended location is Canada due to how high demand and the significant emphasis on sustainability, ethics and reliability.

Introduction

In the Haldon Strategy 2021-2026 summary, it was noted that Haldon has been experiencing a production deficit since Q2 2018 due to increasing demand for its cars. To increase production levels of its vehicles in the next 10 years, Haldon has decided to invest in a new car manufacturing factory in one of 3 locations that were concluded from a memo documented by Haldon's Opportunity Exploration Team in Sydney. The 3 models of vehicles that will be produced in each of the factories include the "Cubic" which is a Hatchback, the "Traveller" which is a family car and the "Adventurer" which is 4x4 SUVs.
The initial upfront investment cost for each factory comes in at 20 million AUD.

The purpose of this report was to determine the best country to set up a new car manufacturing factory for Haldon, based on factors that are consistent with Haldon's 3 Pillars of Strategy which are production growth, band strength and responsibility and positive impact on new markets. As such the factors that have been considered, such as Net Present Value (NPV), Demand, Environmental Impact, Worker's Quality of Life, Reliability and Quality of vehicle. The methods that are employed to analyze all 5 of the factors are the Decision-Making framework that acts as the guiding principle in setting up the objectives/factors, applying the payoff matrix for all objectives and finally assessing the combined performance of each country on all objectives with the payoff matrix. In addition, the linear optimisation technique is employed using the given Matlab script to evaluate and produce the maximum profit and the net present value for each country. Besides that, the Demand, Environmental Impact, Worker's Quality of Life and Reliability and Quality of each country will be assessed and incorporated in the final payoff matrix to make a recommendation on which country to invest in.

Methods

Decision-Making Framework

It is a methodology that is developed to simplify the process of making high-quality decisions. The purpose of this framework is to help the decision maker to make good decisions that is consistent with the decision maker values such that it can maximise the chance of a good outcome. This methodology is divided into 3 main phases, that are the framing phase, the modelling phase and the assessing phase.

The goal of the framing phase is to establish relationships between the main values that matter to us, and it is also arguably the most important phase as it sets the foundation for the decision problem. There are 3 key interrelated areas to consider in this step. The first key area is defining the context of the decision problem, the second key area is using the context to identify appropriate objectives and their attribute scales, and the third key area is the identification of alternatives. Turns out the 3 alternatives are the 3 pre-defined countries given in the memo (the Haldon Opportunity Exploration Team in Sydney) which are Australia, Canada and Indonesia.

The goal of the modelling phase is to reach an initial decision based on the combined performance of each alternative on all the objectives against one and another. There are 3 important sub-steps to consider which are setting up the payoff matrix which is one of the most simple and effective tools in making a good decision, converting objectives' attribute scales to common values and the distribution of weights to each of the objectives to signify their relative importance in the final decision.

The last phase is the assessing phase which involves making trade-offs between objectives and the analysis of how the weightings of the objectives affect the final decision.

Linear Optimisation

It is one of the simplest forms of an optimisation technique in the mathematical field. The goal of this technique is to find some combinations of the values of the variables such that it maximises or minimises the objective function.

And in our case, the objective function is the profit function that represents the amount of profit a car manufacturing factory can produce in each of the countries based on a combination of the production of the 3 models of vehicle that Haldon will be selling to each country. To obtain the optimal profit, we have to calculate the best combination of the production of the 3 models of vehicle in each of the countries by assessing the amount and cost of materials needed to produce each model of vehicles, the retail price of each of the model of vehicles, the labour cost for each model of vehicles, the total number of vehicles produced per year and the operating expenses of each factory in each country.

Source of Data

The data that were collected are all in accordance with the objectives that serve to distinguish the 3 alternatives, Australia, Canada and Indonesia. In terms of the sources of the data, most of the data came from the handouts that were given by Haldon as they constituted 3 out of the 5 objectives, whereas the data for the other 2 objectives were substantiated from online sources.

The data from the handouts are about the financial and the manufacturing aspects of the proposed factory in each of the countries. The data include the production capacity of vehicles per year, the number of employees, the initial investment amount, the labour cost, the amount and cost of materials for producing each model of the vehicles, the operating cost of the factory, the reliability ratings and the environmental impact of the car manufacturing process. The data that were gathered from online resources are about the market and ethical aspects of the expansion. The data involve the demand for vehicles in each of the countries, the human rights index[2] that specified how well individual rights are founded and respected in each country based on a score that ranges between -3.8 to 5.4, the global rights index[4] that measures the democracy of workers and their rights, the union membership[3] shows the percentage of employees that are in a union that protects and empowers them, the freedom rights index[1] that measures the social and economic freedom based on 76 indicators.

All the data collected are numerical in nature.

Analysis and Application

The Decision-Making Framework will be the main driver for this analysis. Following the first phase of the framework, the context of our analysis is about selecting the best factory in one of the 3 countries, Australia, Canada and Indonesia based on 5 objectives such as the Net Present Value (NPV), the Demand, the Environmental Impact, the Worker's Quality of Life and the Reliability/Quality of the vehicle. These objectives are formulated in conjunction with Haldon values.

Moving on to the modelling phase also known as the second phase, we will be applying the payoff matrix which is the bread and butter of our decision analysis as it is the tool that will be the one that we used to choose the best country. The payoff matrix works by distributing weights across all 5 of the objectives such that it sums up to 1 signifying a normalised weight. The weight here essentially tells you how desirable an objective is compared to the others such that the higher weighted ones will be more preferred than the lower weighted ones. Following that, it will convert all the attribute scales of each of the 5 objectives into a common scale of 0 to 100. This is done to ensure that the performance of the countries on multiple objectives is coherent. At the end of it, it will generate a summation value that is weighted and normalised for each of the countries where the highest will be the winner.

In terms of the objectives for each country, only the Net Present Value and maximum profit involved the use of the Linear Optimisation technique. This is because NPV calculation uses the maximum profit value as its metric. The maximum profit value for each of the countries is calculated using Linear Optimisation via the use of Matlab Script that was provided by Kate Bridges in the IT department of Haldon. As stated in the Linear Optimisation section above, the calculation for the maximum profit of each country works by inputting all the relevant information for profit and outputting a maximal profit value based on the best combination of the total number of the 3 models of vehicles. That is how the NPV and maximum profit of each country is calculated.

As for the objective, “Worker’s Quality of Life”, it is calculated using the payoff matrix with 5 other objectives such as job creation, union membership, freedom index, human rights index and the global rights index. The final normalised weighted summation value for each of the countries will then be used as the score in the primary payoff matrix. Furthermore, the environmental impact value is formulated using the Total Environmental Impact (TEI) formula that we devised. It takes the summation of the CO_2 emission, NO_x emission and water used in equal parts and multiply by the total number of projected vehicles produced yearly in each factory for each of the countries across 10 years. As for the other objectives, their natural values are used directly.

Findings

In this section, a breakdown of all the numerical results for each of the objectives will be shown. These results will be used in final payoff matrix to provide the final recommendation.

Maximum Profits and Net Present Value (NPV)

As mentioned in the method section for analysis and application, the maximum profit for each country is calculated using the data that were provided to us in the handouts given by Haldon. Specifically, the data that were used are basic data about the factory in each country and the material availability and cost to build each model of vehicle.

Location	Production capacity (vehicles per year)	Number of Employees	Initial Investment (AUD)	Labour cost per vehicle produced (proportion of retail price, ex. GST)
Australia	1200	200	20 000 000	0.5
Indonesia	2100	300	20 000 000	0.2
Canada	900 until end 2024 1200 from 2025	250	20 000 000	0.45

Table 1: Basic data for each of the factories from Haldon

According to table 1 above, it is shown that all 3 factories will have the same estimated upfront investment cost of 20 million AUD. In terms of the production capacity, Indonesia is trailing at the top with 2100 vehicles production per year and the lowest labour cost. In contrast, Australia and Canada both have significantly higher labour cost and significantly lower production capacity at 1200 vehicles production per year for Australia whereas Canada has 900 vehicles production per year from 2021 to 2024 and beyond that, it will have the same 1200 vehicle production per year as Australia.

As stated in the handouts given by Haldon, the study on the availability and cost of materials to produce motor vehicles shows that Indonesia has the highest materials availability and the lowest materials cost in comparison to Australia and Canada. On the contrary, both Australia and Canada have significantly higher materials cost and marginally lower materials availability.

Country	Projected Maximum Profits ($AUD)
Australia (2021+)	$6.224447 * 10^6$
Indonesia (2021+)	$9.276735 * 10^6$
Canada (year 2021-2024)	$5.368300 * 10^6$
Canada (year 2025+)	$6.910900 * 10^6$

Table 2: Maximum Profit in AUD for each country per year

By computing all the information above mathematically in the given Matlab Script using linear optimisation, we were able to arrive at the projected maximum profit for each of the countries as shown in table 2 above. Assuming that the production capacity of vehicles for each factory stays the same and that all vehicles are sold, Indonesia can only achieve the projected maximum profit if and only if 94.43% of the 2100 vehicles produced per year comprised of only the “Cubic” and the “Traveller” models. Similarly for Australia, 89.25% of the 1200 vehicle produced per year would be the desired combination of the models of vehicles. However, Canada in the period of 2021 to 2024, must have 100% of the 900 vehicles produced per year to be the “Adventurer” model. In the year after 2024 where Canada ramps up its production capacity to 1200 vehicles, it will have to have 100% of the produced vehicles to comprised of only the “Cubic” and the “Adventurer” models. This are all assuming they are possible. In terms of the profits in the year 2021 to 2024, Indonesia has the highest at 9,276,735 AUD while Canada has the lowest at 5,368,300 AUD. In contrast, in the year after 2024, Indonesia remains the highest while Canada beats out Australia as the second highest at 6,910,900 AUD.

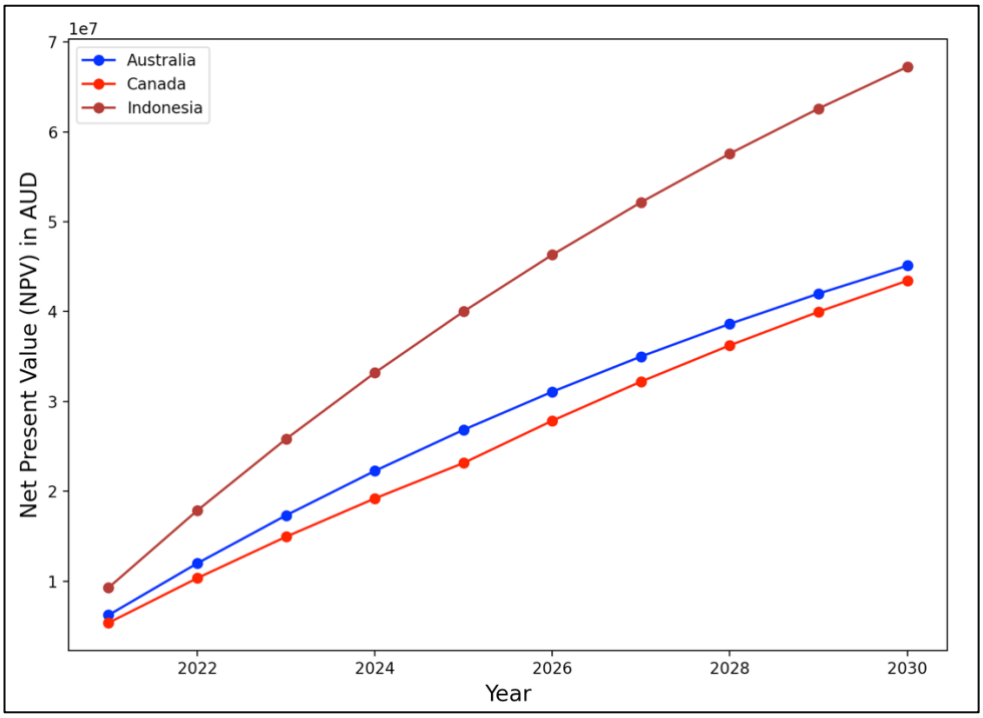

Figure 1: Plot of the Net Present Value of each country from year 2021 to 2030

Subsequently, the Net Present Value of each factory is computed with the help of the Matlab script with the operating cost of each factory and discount rate given by Haldon, and the projected maximum profit of each factory as its metrics. The result is shown in Figure 1 above. It can be seen that Indonesia has the highest Net Present Value in the 10 years as compared to the other 2 countries. In contrast, Australia beats out Canada by a small margin landing it as the second-highest followed by Canada.

Demand

Below are the total number of new Passenger vehicles and SUVS sales 2019 obtained through official online sources.

Country	Total new Passenger vehicles and SUVS sales in 2019
Australia	799,245
Canada	1,328,548
Indonesia	798,813

Table 3: Total number of new Passenger + SUVS vehicle sales in 2019 for each country[5][6][7][8][9][10]

According to table 3 above, Canada has the highest total number of new Passenger vehicles and SUVS sales at 1,328,548 vehicles. Meanwhile, both Australia and Indonesia have very similar numbers at 799,245 vehicles for the former and 798,813 vehicles for later where Australia wins out by a small margin landing it at the second-highest followed by Indonesia.

Environmental Impact

Below shows the study of the environmental impact of a car manufacturing process in all 3 of the countries given by Haldon in one of the handouts.

Country	CO_2 emissions (1000 tonnes/car produced)	NO_x emissions (tonnes/car produced)	Water used (m^3/car produced)
Australia	7	60	165
Canada	6	62	150
Germany	5	63	147
Indonesia	10	68	215
United States	8	62	180

Table 4: Environmental impact of a typical car manufacturing plant in 5 countries

Country	Total Environmental Impact (TEI) (Lower the better)
Australia	2,784,000
Canada	2,354,400
Indonesia	6,153,000

Table 5: Total Environmental Impact for each country in 10 years

As stated in the method section of analysis and application, the total environmental impact of each country is calculated by multiplying the sum of all the pollutants, CO_2 emissions, NO_xemission and water used with the total number of cars produced yearly. As shown in Table 5 above, Canada has the Lowest TEI score at 2,354,400 which is 15% better than Australia and 161% better than Indonesia.

Worker's Quality of Life

Below shows all 5 of the objectives for each country that are used to calculate the Worker's Quality of Life value.

Country	Australia	Canada	Indonesia
Job Creation (Number of employees)	200	250	300
Union Membership (%)	14.5	28.4	7
Freedom Index (Higher the better)	5	6	68
Human Rights Index (Higher the better)	1.75	2.79	-0.43
Global Rights Index (Lower the better)	3	2	5

Table 6: Shows the numerical results of each objective for each country

As shown in Table 6 above, Indonesia is the lowest in 4 out of the 5 objectives. As such, Indonesia only has 7% of its workforce that joined workers' unions[3], It also ranked 68 out of 162 countries in the freedom index study[1], It scores -0.43 in the Human rights index[2] study and it scores 5 in the Global rights index[4] study. The only objective where Indonesia is the highest is in Job Creation at 300 employees. In contrast, Canada is the highest among the 3 countries in the 4 ethical objectives followed by Australia as the second highest. However, Canada comes in as second in the job creation objective at 250 employees followed by Australia that has the lowest at 200 employees.

Criteria	Wt	Score		
		Australia	Canada	Indonesia
Job Creation	0.3	0	50	100
Union Membership	0.05	42.3	100	0
Freedom Index	0.15	100	98.41	0
Human Rights Index	0.2	67.7	100	0
Global Rights Index	0.3	66.6	100	0
Total	1	50.64	84.76	30

Table 7: Payoff-Matrix for the Worker's Quality of Life

As seen in Table 7 above, we employed the payoff matrix as the tool for calculating the combined performance of all 5 of the objectives for each of the countries concerning the Worker's Quality of Life. As shown, a weighting of 100% is distributed across all 5 of the objectives to signifying their relative importance as stated in the Decision-Making Framework section of the method. Job Creation and Global Rights Index[4] are given the highest weighting of 30% each, the Human Rights Index[2] is given the second-highest weighting of 20% followed by the Freedom Index[1] with a weighting of 15% and at last, the Union Membership[3] is given the lowest weighting of 5%. In terms of the score, each of the objectives natural values are converted to a common value of 0 to 100 with the use of value functions. Finally, a total weighted sum for each country is produced where Canada is highest at 84.76 followed by Australia at 50.64 and Indonesia that has the lowest at 30.

Reliability and Quality of vehicle

Below shows the data on the failure rates of the different brands of vehicles that have driven for 100,000 km, from different countries.

Country	Normalised average failure rate (NAF)
Australia	0.9
Canada	1.0
France	1.0
Germany	0.8
Indonesia	1.3
United States	1.1
Sweden	1.0

Table 8: Normalised failure rates per country

Based on Table 8 above, Indonesia has the highest NAF of vehicles as compared to Australia and Canada. As a consequence, Indonesia's produced vehicle has a 30% higher chance of breaking down than the rest. In contrast, Australia has the lowest NAF among the 3

countries in question such that Australia's produced vehicles are 10% less likely to break down.

Discussion

As seen in the findings, the result for the projected maximum profit in 10 years shows that Indonesia is the highest amongst the 3 countries at 9,276,735 AUD. This is not surprising as the data that were provided to us by Haldon pointed towards this result. From the data, we can see that Indonesia triumphs in every single metrics that were used to calculate the projected maximum profit. As such, it has the highest production capacity of vehicles per year, the largest number of potential employees coupled with the lowest labour cost per vehicle produced, the highest materials availability coupled with the lowest materials cost and the lowest yearly operating expenses for its factory at 500,000 AUD. Conversely, both Canada and Australia lose out in every single metrics as compared to Indonesia. For instance, they have significantly higher labour cost, materials cost, and factory yearly operating expenses where both countries exceed 1,000,000 AUD. As a consequence, the Net Present Value of Indonesia is the highest at 67,722,746 AUD in comparison to the other 2 countries each of which is around 43-45 million AUD. This means that Indonesia would be the best option in aspect of financial gain.

In terms of demand, Canada has the highest number of new passenger vehicles and SUVs sales in 2019 in comparison to the other 2 countries. This is because the total number of new car sales in 2019 inclusive of all segments in Canada is at 1,921,441(units)[6][7][8][9] which is 1.8 times higher than Australia's 1,062,876(units)[5] and 1.86 times higher than Indonesia's 1,030,126(units)[10]. Therefore, Canada looks to be the most promising market for Haldon. Conversely, Australia and Canada have one of the highest numbers of cars per 1000 inhabitants in the world, Australia has 717[12] and Canada has 607[12]. Although there is a disparity between the two, the difference in the population where Canada's population is 1.5 times the population of Australia essentially offsets the difference. However, Indonesia has an astoundingly low number of cars per 1000 inhabitants of 60[12] has a disproportionately greater population as compared to the other 2 countries. This revelation lands Indonesia as the most potential market out of the 3.

According to World Bank, International Comparison Program database, the GDP per capita for Canada is 57129.39 AUD[12], Australia is 57750.03 AUD[12] and Indonesia is 13265.52 AUD[12]. As shown, Canada and Australia both has very similar GDP per capita but Australia wins by a small margin whereas Indonesia lands as the lowest in the bunch. This information is important as it supports and supplements the next 3 objectives that I will be discussing very well.

In terms of environmental impact, as displayed in the findings, the Total Environmental Impact score for both Australia and Canada comes close to one and another. However, Canada ultimately beats out Australia as the best due to the lower numerical quantities in 2 out of the 3 pollutants as provided in Table 4 above. This comes as no surprise because both Australia and Canada have very similar GDP per capita and are among the highest in the world[12]. As pointed out in the Environmental Performance Index Study of 2020[11], good

policies are often associated with wealth (GDP per capita). A wealthy country often has the economic means to invest in policies and programs that can lead to good outcomes and in this case that would be a sustainable car manufacturing process. Therefore, Canada looks to be the best in the environmental aspect of the decision making.

This is also true for the next objective known as "Worker's Quality of Life". As shown in the findings, Canada wins out as the best for Worker's Quality of Life with a total weighted sum of 84.76. This is due to Canada being one of the most progressive and democratic countries in the world where laws surrounding workers are very well-established and committed to by good governance from the government. Of course, we cannot disregard Australia as it is also very well-rounded in this regard as it has very similar scores in the ethical fields of worker's rights as compared to Canada as displayed in the findings. On the other hand, Indonesia which has one of the lowest GDP per capita in the world and is still a developing country with weak individuals and workers laws, lands as the weakest in this area. This means that Canada is the best place for any aspiring workforces.

For the reliability and quality of vehicles, Indonesia has the worse normalised average failure rate amongst the 3 countries. This is likely due to Indonesia being a developing country that has low minimum wage and laws that lag behind the likes of Australia and Canada.

Recommendation and Conclusion

Objectives		Alternatives		
Criterion	Wt	Australia	Canada	Indonesia
Net Present Value, NPV	0.40	7	0	100
Demand	0.2	0.1	100	0
Environment Impact	0.1	88.7	100	0
Workers' Quality of Life	0.1	37.69	100	0
Reliability/Quality	0.2	100	75	0
	Total			
	1	35.46	55	40

Table 9: Final Payoff-Matrix

As shown in Table 9 above, this is what the final payoff matrix looks like. It contains all 5 of the primary objectives such as Net Present Value, Demand, Environmental Impact, Worker's Quality of Life and Reliability and Quality of vehicle. According to the Modelling phase of the Decision-Making Framework as explained in the method section, each of the objectives will be given a weight to signify their relative importance in making the final decision. We had

decided early on that the distribution of the weightings should mostly favour the more financially driven objectives. As such, we decided to give Net Present Value a weight of 40% which is the highest among the 5 objectives, followed by Demand and Reliability and Quality of vehicle each given a weight of 20%. The least favoured objectives are Environmental Impact and Worker's Quality of Life each given a weight of 10%. Subsequently, we converted all the objectives' natural values into a common value of 0 to 100.

Finally, by finding the normalised weighted sum of each country for all of the objectives. The final recommended country to invest in is Canada, followed by Indonesia and sitting in the last place is Australia.

This result might seem contradictory to our goal of being profit-oriented as Canada performs the worse for Net Present Value. Canada ended up being the final recommendation due to it performing outstandingly in 3 out of the 5 objectives such as demand where it is the largest by a significant margin as shown in table 3 above, environmental impact where it has 15% better TEI scores than Australia and 161% better TEI scores than Indonesia, and Worker's Quality of Life where it triumphs over almost every single sub-objectives that constituted the Worker's Quality of Life landing it as the highest and the best amongst the 3 countries. This means that having a factory in Canada can lead to long term growth due to high demand and great reputation due to the significant emphasis on sustainability, ethics and reliability.

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Appendices

Appendix 1: Linear Optimisation

a. The variables represent the models of the vehicles:
   i. x_1= Cubic, x_2= Traveller, x_3= Adventurer
b. Objective function also known as "Profit function": General form
   i. $f(x_1, x_2, x_3) = [(Retail\ Price\ of\ Cubic)(1 - labour\ cost) - (Materials\ cost)]x_1 + [(Retail\ Price\ of\ Traveller)(1 - labour\ cost) - (Materials\ cost)]x_2 + [(Retail\ Price\ of\ Adventurer)(1 - labour\ cost) - (Materials\ cost)]x_3$
c. Example: Australia –
   i. Material constraints:
      1. Steel: $400x_1 + 500x_2 + 520x_3 \leq 7 \times 10^5$
      2. Glass: $50x_1 + 70x_2 + 40x_3 \leq 7 \times 10^4$
      3. Rubber: $70x_1 + 80x_2 + 150x_3 \leq 1 \times 10^5$
      4. Paint: $30x_1 + 40x_2 + 50x_3 \leq 5 \times 10^4$
   ii. Number of cars produced constraint:
      1. $x_1 + x_2 + x_3 \leq 1200$
   iii. The profit function:
      1. $f(x_1, x_2, x_3) = 5482x_1 + 6680x_2 + 6328x_3$

Appendix 2: Net Present Value Formula (NPV)

a. $NPV = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$
   i. $t = 10\ years$
   ii. $R_t = Maximum\ Profit\ for\ each\ factory$
   iii. $i = discount\ rate\ of\ 8\%$

Appendix 3: Total Environmental Impact Formula (TEI)

a. $TEI = \sum_{i=1}^{10}(C_i + N_i + W_i) \times Y_i(t)$
   i. $C_i = CO_2\ emisions\ per\ car\ produced\ in\ country\ i$
   ii. $N_i = NO_x\ emisions\ per\ car\ produced\ in\ country\ i$
   iii. $W_i = Water\ used\ per\ car\ produced\ in\ country\ i$
   iv. $Y_i(t) = production\ capacity\ of\ vehicles\ in\ country\ i, t\ years\ after\ 2021$

Appendix 4: Payoff Matrix

a. Example of Value function calculation:
   i. General form:
      1. $y = mx + c$

a. y = y-axis of a linear function (the common value)
b. x = x-axis of a linear function (the objectives natural values)
c. m = change in slope
d. c = y-intercept (the offset to ensure the common value is between 0 and 100 for every single objectives)

ii. Value function for Job creation:

1. $V_{JC} = x_{NE} - 200$
   a. $V_{JC} = common\ value\ for\ job\ creation$
   b. $x_{NE} = the\ number\ of\ employees\ of\ each\ country$
   c. $m = \frac{100-0}{300-200} = \frac{100}{100} = 1$
      i. Take the difference between (300,100) and (200,0) where the former is the coordinate for Indonesia and the latter is the coordinate for Australia.
      ii. We assume that the country with the lowest natural value will be represented by the common value of 0 and the highest will be represented by the common value of 100. The rest are between 0-100.
   d. c = -200
      iii. This offset ensures that the common value is in the range of [0,100].