A Report for Second Model

SM

2023-08-19

Forecasting the Outcomes of A New Product Launch Using Monte Carlo Simulation

A simulation practice by SM

Background information

A fragrance retailer planned to launch a new product to boost sale. The product development team proposed three product ideas: perfume, scented candle and Chinese perfume pouch.The sale department gathered data from market surveys, and forcasted sales for three proposed products, using the Monte Carlo (MC) Simulation method.

Based on the outcomes of the simulation, the product with the best simulation result was chosen for the product line.

Building the model

The first step to decision analysis using MC simulation was buidling the conceptual model. The model was built based on the information gathered from market surveys and experts' opinions.

The model shows the pathway for decision analysis, and outlines benefits, costs and risks that can impact decision making.

Building the input table

Next, an input table was made based on the variables outlined in the conceptual model.

```
df<- read.csv("Input_perfume.csv")
knitr::kable(df)
```

variable	distribution	lower	median	upper	label	Description
n_years	const	3.0e+00	NA	3.0e+00	Number of years	Period of simulation in year
var_CV	posnorm	5.0e+00	NA	1.0e+01	Coefficient of variation	Coefficient of variation
discount_rate	posnorm	3.0e+00	NA	5.0e+00	Discount rate	Discount rate (%)

variable	distribution	lower	median	upper	label	Description
		NA	NA	NA		
income_tax	const	1.0e-03	NA	1.0e-03	Percent income tax	Percent rate for taxable income (%)
Rent_yearly	const	2.0e+04	NA	2.0e+04	Shop rental fee	Annual shop rental fee (USD)
Utility_bill	posnorm	3.0e+03	NA	5.0e+03	Utility bill	Annual utiltiy bill (USD)
Delivery_cost	posnorm	2.0e+03	NA	8.0e+03	Delivery cost	Annual cost of delivery or transport (USD)
Salary_cost	const	1.0e+04	NA	1.0e+04	Salary for staff	Salary for the current shop assistant for a year (USD)
Insurance_cost	const	1.0e+03	NA	1.0e+03	Insurance for shop	Annual fee for general liability insurance (USD)
Renovation_cost	posnorm	3.0e+03	NA	6.0e+03	Shop renovation	One-time cost for shop renovation or decoration to suit the theme for new product launching (USD)
Advertisement_cost	posnorm	5.0e+03	NA	8.0e+03	Advertisement cost	Cost of advertisement for new product launching (USD)
		NA	NA	NA		
Current_income	posnorm	2.0e+06	NA	4.5e+06	Income from current sales	Current annual income of the shop (USD)
		NA	NA	NA		
Perfume_production_loss	posnorm	1.0e+03	NA	5.0e+03	Cost of production loss for perfume	Annual expected cost of loss occurs during production, transports and accidents for perfume (USD)
Candle_production_loss	posnorm	1.0e+03	NA	5.0e+03	Cost of production loss for candle	Annual expected cost of loss occurs during production, transports and accidents for candle (USD)
Pouch_production_loss	posnorm	5.0e+02	NA	3.0e+03	Cost of production loss for perfume pouch	Annual expected cost of loss occurs during production, transports and accidents for perfume pouch (USD)
		NA	NA	NA		
Perfume_cost_raw	posnorm	5.0e+02	NA	1.5e+03	Cost of raw material for perfume	Cost of raw material (ingredients and packaging) for making a 200-unit batch of perfume (USD)
Perfume_cost_production	posnorm	2.0e+02	NA	5.0e+02	Cost of production for perfume	Cost of production for perfume (including the cost of utensils) (USD)
Chance_perfume_market	norm	4.0e-01	NA	8.0e-01	Chance of good market for perfume	Chance of having good market for new perfume launching (%)
Chance_perfume_sale_festive	norm	2.0e-01	NA	4.0e-01	Chance of sale increase for perfume	Chance of increased perfume sales during holiday and festive season (%)
Perfume_festive_sale_volume	posnorm	5.0e+05	NA	1.0e+06	Increased perfume sales duirng festive season	Expected increase in perfume sales during festive season (unit)
Perfume_sale_increase	norm	3.0e-03	NA	5.0e-03	Increased perfume sales if good market	Expected increase in perfume sales if market is good (%)
Perfume_sale_volume	posnorm	1.0e+07	NA	1.5e+07	Expected sale volume for perfume	Expected annual perfume sales (unit)
Perfume_selling_price	posnorm	2.0e+01	NA	3.0e+01	Selling price per perfume unit	Selling price per unit (or bottle) of perfume (USD)
Chance_perfume_competition	norm	1.0e-03	NA	3.0e-03	Chance of reduced unit selling price for perfume	Chance of reduced selling price per unit of perfume due to competition if market is good (%)

variable	distribution	lower	median	upper	label	Description
Reduced_perfume_selling_price	truncnorm	1.0e-03	NA	5.0e-03	Percent reduction of perfume selling price	Estimate percent reduction of unit selling price for perfume due to competitive pricing (%)
Candle_cost_raw	posnorm	2.0e+02	NA	8.0e+02	Cost of raw material for candle	Cost of raw material (ingredients and packaging) for making a 300-unit batch of candle (USD)
Candle_cost_production	posnorm	1.0e+02	NA	3.0e+02	Cost of production for candle	Cost of production for scented candle (including the cost of utensils) (USD)
Chance_candle_normal_market	norm	6.0e-01	NA	8.0e-01	Chance of good market for candle	Chance of having good market for new candle launching (%)
Chance_candle_sale_festive	norm	6.0e-01	NA	7.0e-01	Chance of sale increase for candle	Chance of increased candle sales during holiday and festive season (%)
Candle_festive_sale_volume	posnorm	2.0e+06	NA	5.0e+06	Increased candle sales duirng festive season	Expected increase in candle sales during festive season (unit)
Candle_sale_increase	norm	2.0e-02	NA	5.0e-02	Increased candle sales if bad market	Expected increase in candle sales if market is good (%)
Candle_sale_volume	posnorm	1.5e+07	NA	3.0e+07	Expected sale volume for candle	Expected annual candle sales (unit)
Candle_selling_price	posnorm	5.0e+00	NA	8.0e+00	Selling price per candle unit	Selling price per unit (or pcs) of candle (USD)
Chance_candle_competition	norm	1.0e-02	NA	4.0e-02	Chance of reduced unit selling price for candle	Chance of reduced selling price per unit of candle due to competition if market is good (%)
Reduced_candle_selling_price	norm	1.0e-03	NA	5.0e-03	Percent reduction of candle selling price	Estimate percent reduction of unit selling price for candle due to competitive pricing (%)
Pouch_cost_raw	posnorm	2.0e+02	NA	6.0e+02	Cost of raw material for perfume pouch	Cost of raw material (ingredients and packaging) for making a 350-unit batch of perfume pouch (USD)
Pouch_cost_production	posnorm	5.0e+01	NA	1.5e+02	Cost of production for perfume pouch	Cost of production for perfume pouch (including the cost of utensils) (USD)
Chance_pouch_normal_market	norm	6.0e-01	NA	7.0e-01	Chance of good market for perfume pouch	Chance of having good market for new perfume pouch launching (%)
Chance_pouch_sale_festive	norm	6.0e-01	NA	7.0e-01	Chance of sale increase for perfume pouch	Chance of increased perfume pouch sales during holiday and festive season (%)
Pouch_festive_sale_volume	posnorm	2.0e+06	NA	6.0e+06	Increased perfume pouch sales duirng festive season	Expected increase in perfume pouch sales during festive season (unit)
Pouch_sale_increase	norm	3.0e-02	NA	6.0e-02	Increased perfume pouch sales if bad market	Expected increase in perfume pouch sales if market is good (%)
Pouch_sale_volume	posnorm	3.0e+07	NA	5.0e+07	Expected sale volume for perfume pouch	Expected annual perfume pouch sales (unit)
Pouch_selling_price	posnorm	3.0e+00	NA	5.0e+00	Selling price per perfume pouch	Selling price per perfume pouch (USD)
Chance_pouch_competition	norm	1.0e-02	NA	3.0e-02	Chance of reduced unit selling price for perfume pouch	Chance of reduced selling price per perfume pouch due to competition if market is good (%)

variable	distribution	lower	median	upper	label	Description
Reduced_pouch_selling_price	N	0.01	NA	5.0e-03	Percent reduction of perfume pouch selling price	Estimate percent reduction of unit selling price for perfume pouch due to competitive pricing (%)

Linking the varibles in R

The net profit for each product was calculated and compared using R program software. The net profit was calculated using the formula: **Net Profit = Sales Volume * (Selling Price - Unit Cost) _ Fixed Costs**

However, the input variables must be strung together first before fitting into the formula.

First, annual costs for rent, utility, delivery or transport, salary, insurance, renovation or decoration and advertisement were summed together as fixed costs. Cost of renovation and advertisment were also considered as recurring annual costs since the retail would need to change decoration and ran advertisements to attract the customers.

```
Fixed_cost <- sum   (Rent_yearly,
                    Utility_bill,
                    Delivery_cost,
                    Salary_cost,
                    Insurance_cost,
                    Renovation_cost,
                    Advertisement_cost)
  Fixed_cost
```

Then, the fixed cost for each product was caculated by adding estimate costs of production loss.

```
# Calculate fixed cost for each new product

  Fixed_cost_perfume <- vv (Fixed_cost + Perfume_production_loss,
                            var_CV, n_years)

  Fixed_cost_candle <- vv (Fixed_cost + Candle_production_loss,
                           var_CV, n_years)

  Fixed_cost_pouch <- vv (Fixed_cost + Pouch_production_loss,
                          var_CV, n_years)
```

The unit cost for each product was also calculated.

```
# Calculate unit cost for each product

  Unit_cost_perfume <- vv ((Perfume_cost_raw +
                             Perfume_cost_production)/ 200,
                           var_CV, n_years)
  Unit_cost_perfume

  Unit_cost_candle <- vv ((Candle_cost_raw +
```

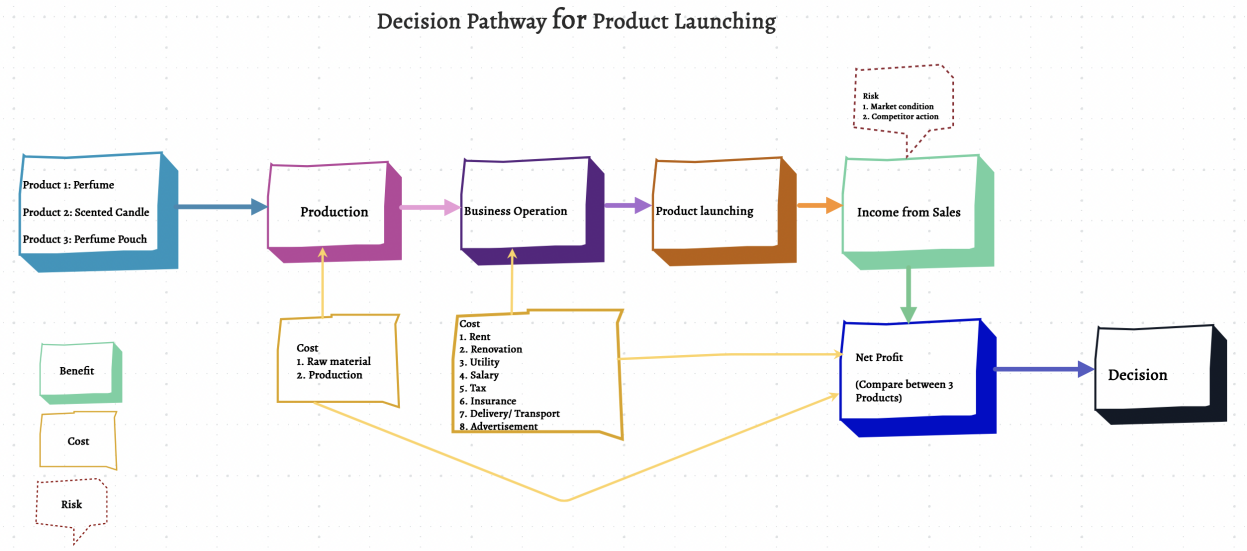

Figure 1: Fig. 1: Conceptual Model

```
                          Candle_cost_production)/ 300,
                         var_CV, n_years)
  Unit_cost_candle

  Unit_cost_pouch <- vv ((Pouch_cost_raw +
                           Pouch_cost_production)/ 350,
                         var_CV, n_years)
  Unit_cost_pouch
```

Then, sale volumes for each product was calculated based on the chance events: "sale increase if the market scenario is good" and "if sale increase during the festive months."

```
# Perfume sale voumes if market is good

  Chance_perfume_market_yes_no <- chance_event(Chance_perfume_market,
                                               value_if = 1,
                                               value_if_not = 0,
                                               n = 1)

  Perfume_sale_volume <- if (Chance_perfume_market_yes_no == 1) {
    vv (Perfume_sale_volume + (Perfume_sale_volume *Perfume_sale_increase),
    var_CV, n_years)
  } else {
    vv (Perfume_sale_volume,
        var_CV, n_years)
  }

# Increase in perfume sale volumes during festive seasons

  Chance_perfume_sale_festive_yes_no <- chance_event(Chance_perfume_sale_festive,
                                                     value_if = 1,
                                                     value_if_not = 0,
                                                     n = 1)
```

```
  Total_perfume_sale_volume <- if (Chance_perfume_sale_festive_yes_no == 1) {
    vv (Perfume_sale_volume + Perfume_festive_sale_volume,
        var_CV, n_years)
  } else {
    vv (Perfume_sale_volume,
        var_CV, n_years)
  }
```

The calculation was repeated for the sale volumes of scented candle and Chinese perfume pouch.

Next was the calcuation of unit selling price for each new product. If the market for new product were good, there would be market competition by the competitors, which could result in reduced unit selling price.

```
# Reduction in selling price due to market competition if good market is good

  Chance_perfume_competitor <- if (Chance_perfume_market_yes_no == 1) {
    vv (Chance_perfume_competitor,
        var_CV, n_years)
  } else {
    Chance_perfume_competitor <- 0
  }

  Chance_perfume_competitor_yes_no <- chance_event(Chance_perfume_competitor,
                                                   value_if = 1,
                                                   value_if_not = 0,
                                                   n = 1)

  Perfume_selling_price_adjusted <- if (Chance_perfume_competitor_yes_no == 1) {
    vv (Perfume_selling_price - (Perfume_selling_price *
                                 Reduced_perfume_selling_price),
        var_CV, n_years)
  } else {
    vv (Perfume_selling_price,
        var_CV, n_years)
  }
```

Calculation was repeated for the unit selling price of scented candle and Chinese perfume pouch.

Gross profit for each product was also calculated to find out the taxable income for each product.

```
# Calculate gross profit

  Perfume_gross_profit <- Total_perfume_sale_volume *
                          (Perfume_selling_price_adjusted - Unit_cost_perfume) -
                           Fixed_cost_perfume

  Candle_gross_profit <- Total_candle_sale_volume *
                         (Candle_selling_price_adjusted - Unit_cost_candle) -
                          Fixed_cost_candle
```

```
  Pouch_gross_profit <- Total_pouch_sale_volume *
                        (Pouch_selling_price_adjusted - Unit_cost_pouch) -
                         Fixed_cost_pouch

# Calculate taxable income

  Perfume_taxable_income <- Perfume_gross_profit + Current_income

  Candle_taxable_income <- Candle_gross_profit + Current_income

  Pouch_taxable_income <- Pouch_gross_profit + Current_income
```

Finally, the net profit and net present value were obtained using the discounting factor.

```
# Calculate Net profit

  Perfume_net_profit <- Perfume_gross_profit + Current_income
                           - (Perfume_taxable_income * income_tax)

  Candle_net_profit <- Candle_gross_profit + Current_income
                          - (Candle_taxable_income * income_tax)

  Pouch_net_profit <- Pouch_gross_profit + Current_income
                         - (Pouch_taxable_income * income_tax)

# Calculate NPV with discount rate

  NPV_perfume <- discount(x = Perfume_net_profit,
                          discount_rate = discount_rate,
                          calculate_NPV = TRUE)

  NPV_candle <- discount(x = Candle_net_profit,
                         discount_rate = discount_rate,
                         calculate_NPV = TRUE)

  NPV_pouch <- discount(x = Pouch_net_profit,
                        discount_rate = discount_rate,
                        calculate_NPV = TRUE)

  return(list(Profit_Perfume = NPV_perfume,
              Profit_Candle = NPV_candle,
              Profit_Pouch = NPV_pouch,
              Cashflow_Perfume = Perfume_net_profit,
              Cashflow_Candle = Candle_net_profit,
              Cashflow_Pouch = Pouch_net_profit))

}
```

Run the Monte Carlo Simulation

The MC simulation was run 2000 times to get the possible outcome distributions for net profit of each product.

```
product_mc_simulation <- mcSimulation(estimate =
                                      estimate_read_csv("Input_perfume.csv"),
                                      model_function = Product_launch_function,
                                      numberOfModelRuns = 2000,
                                      functionSyntax = "plainNames")
```

Results

The result graphs below show higer and wider profit distribution for perfume. Hence, perfume is the most suitable addition to the product line.

```
plot_distributions(mcSimulation_object = product_mc_simulation,
                   vars = c ("Profit_Perfume", "Profit_Candle",
                             "Profit_Pouch"),
                   method = 'hist_simple_overlay',
                   base_size = 7)


plot_distributions(mcSimulation_object = product_mc_simulation,
                   vars = c ("Profit_Perfume", "Profit_Candle",
                             "Profit_Pouch"),
                   method = 'boxplot')


plot_distributions(mcSimulation_object = product_mc_simulation,
                   vars = c ("Profit_Perfume", "Profit_Candle",
                             "Profit_Pouch"),
                   method = 'smooth_simple_overlay')
```

Cashflow Analysis

The cash flow analysis for the three-year simulation period was done, and the cashflow for all three products were stagnant over the years.

```
plot_cashflow(mcSimulation_object = product_mc_simulation,
              cashflow_var_name = c ("Cashflow_Perfume","Cashflow_Candle",
                                     "Cashflow_Pouch"))
```

EVPI and PLS Results

The model did not generate positive evpi values for the three products.

```
evpi_perfume <- multi_EVPI(mc = mcSimulation_table, first_out_var = "Profit_Perfume")
evpi_candle <- multi_EVPI(mc = mcSimulation_table, first_out_var = "Profit_Candle")
evpi_pouch <- multi_EVPI(mc = mcSimulation_table, first_out_var = "Profit_Pouch")


plot_evpi(evpi_perfume, decision_vars = "Profit_Perfume")
plot_evpi(evpi_candle, decision_vars = "Profit_Candle")
plot_evpi(evpi_pouch, decision_vars = "Profit_Pouch")
```

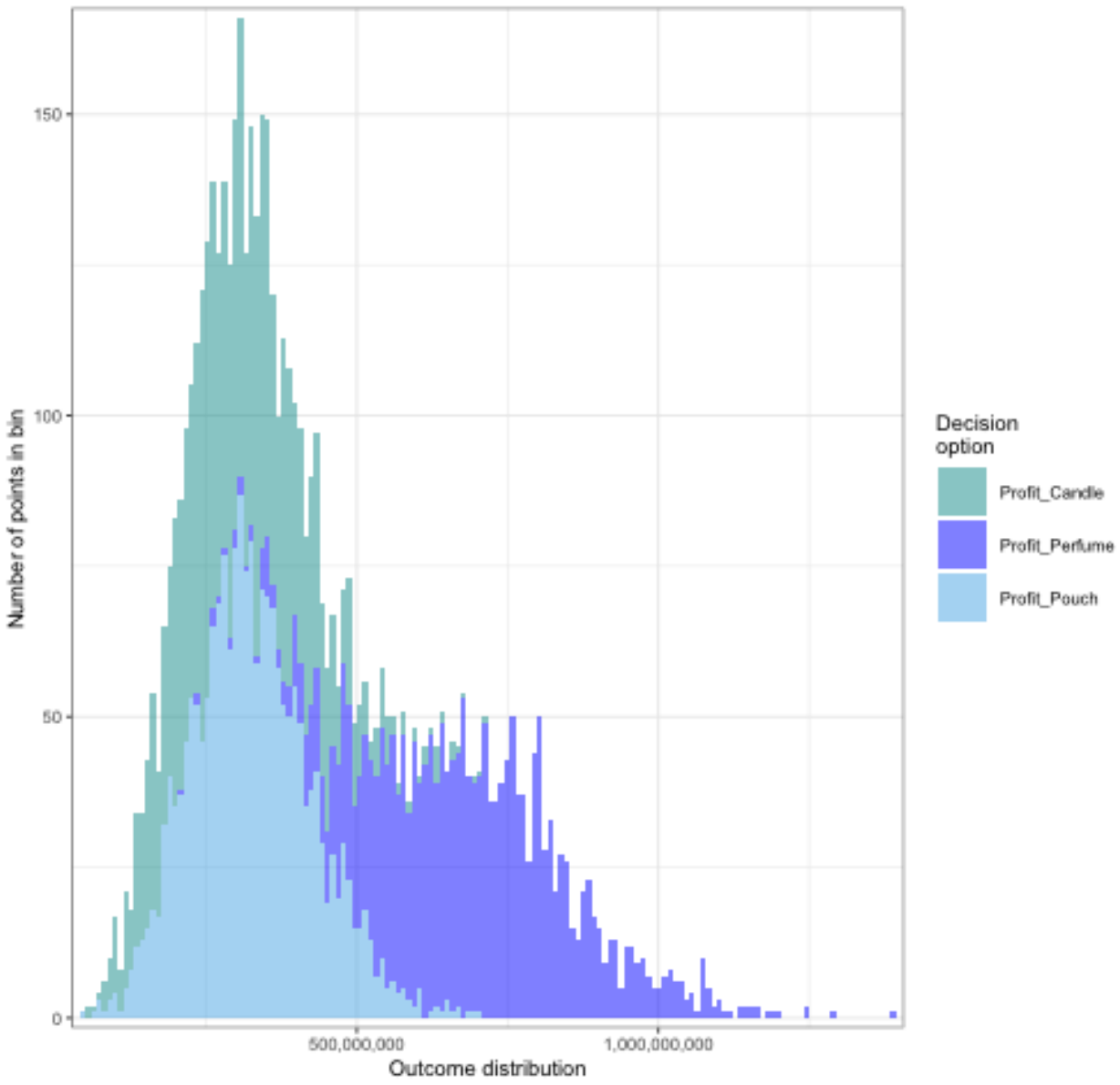

Figure 2: Fig. 2: The Plot Distributions for NPV

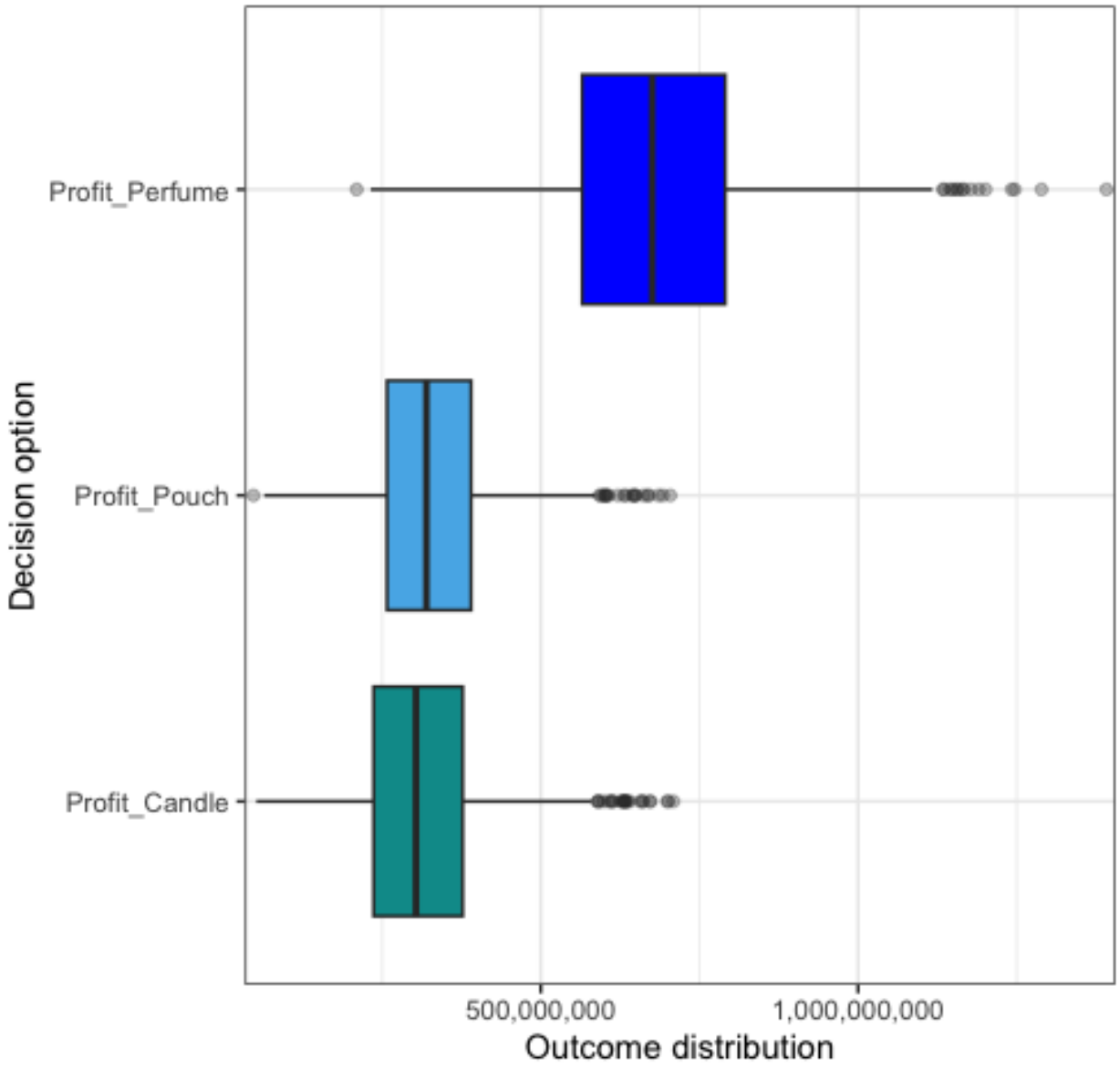

Figure 3: Fig. 3: The Boxplot of NPV

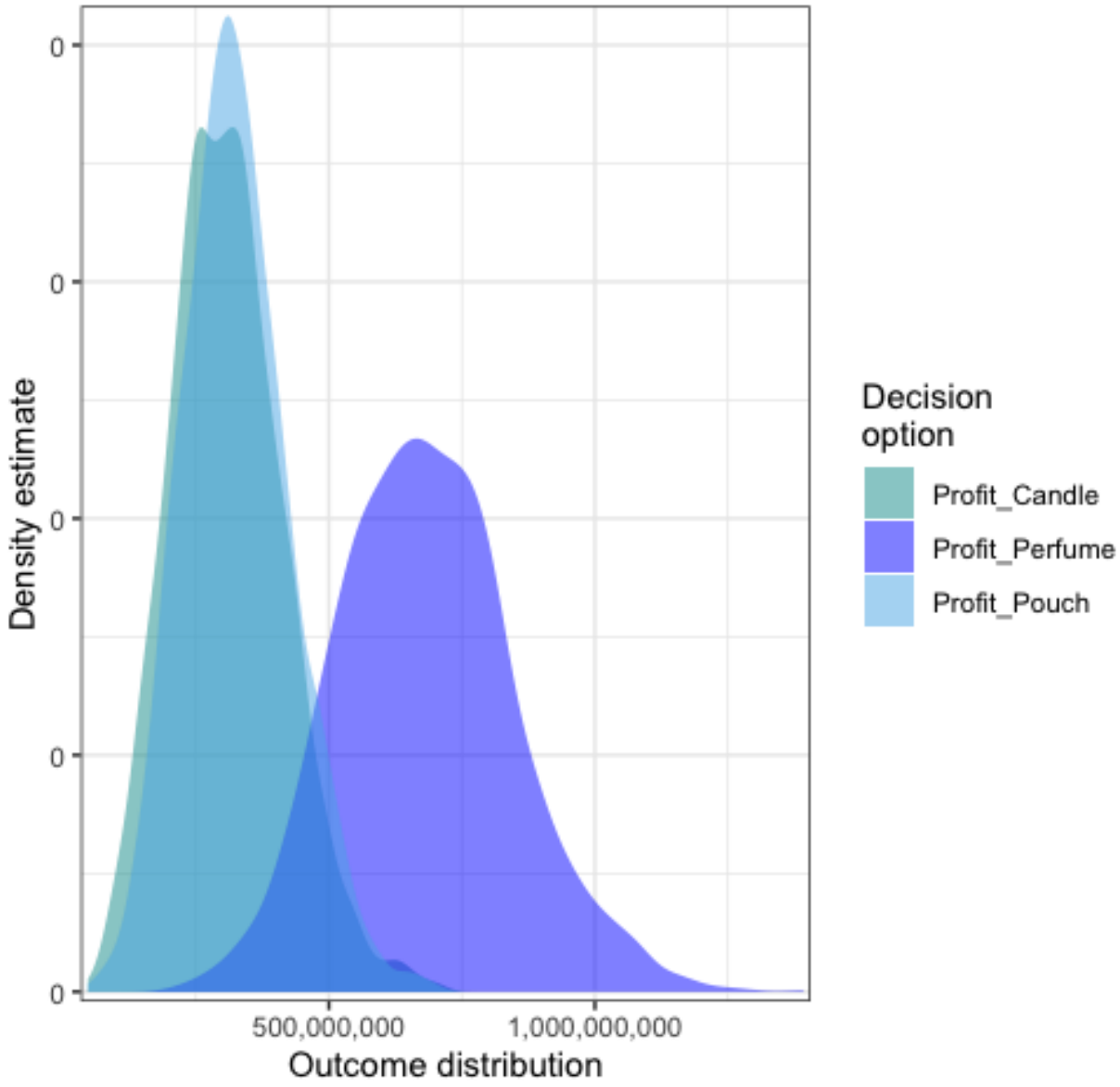

Figure 4: Fig. 4: The Plot Distributions for NPV

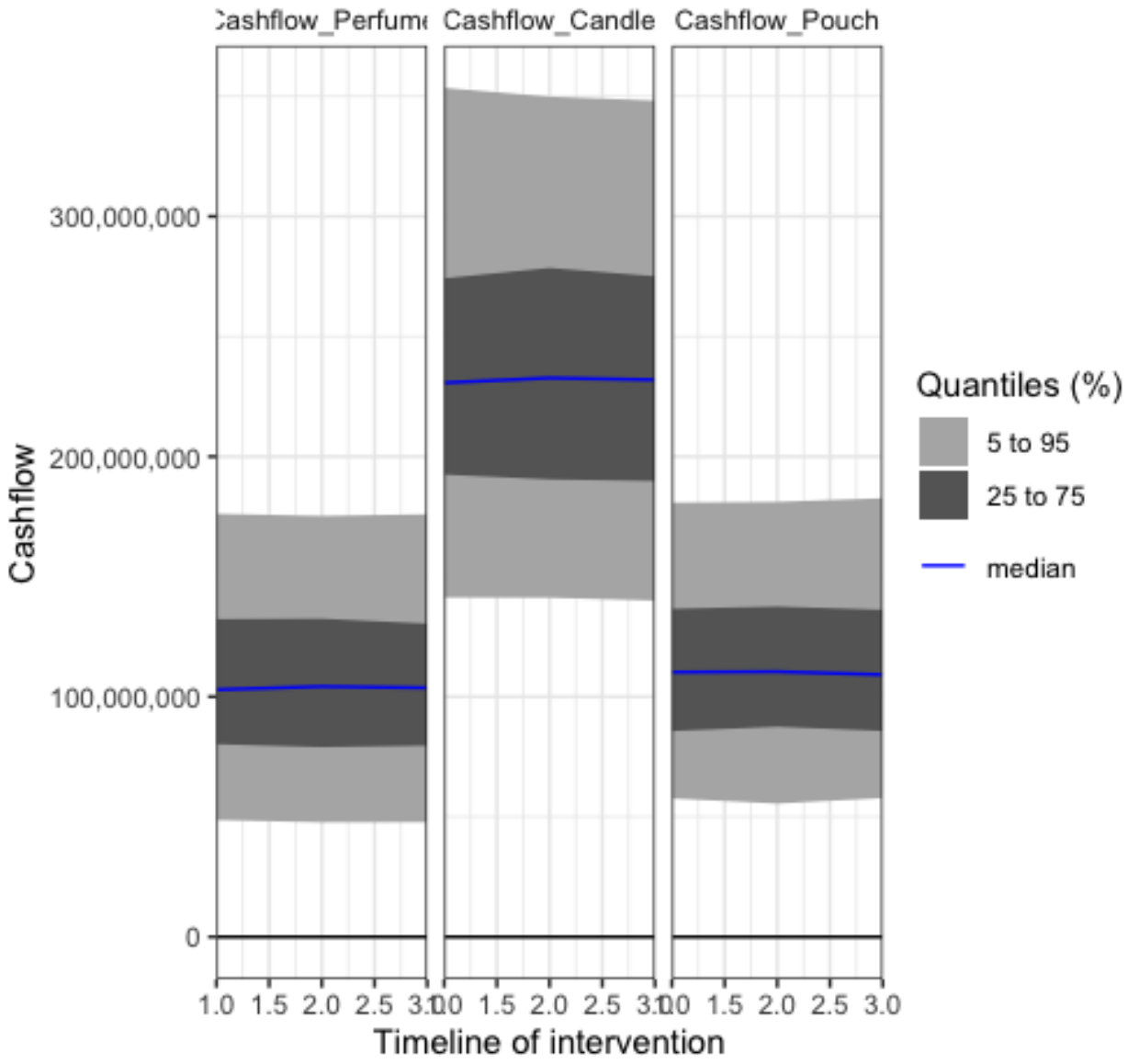

Figure 5: Fig 5: Cashflow Analysis

The PLS results identified the most important variables for the model as unit selling price of perfume, sale volumes of perfume and cost of raw material for perfume. This is in line with the fact that the model predicts higest net profit from perfume sales.

```
pls_result <- plsr.mcSimulation(object = product_mc_simulation,
                                resultName = names
                                (product_mc_simulation$y)[1],
                                ncomp = 1)

plot_pls(pls_result, input_table = input_table, threshold = 0)
```

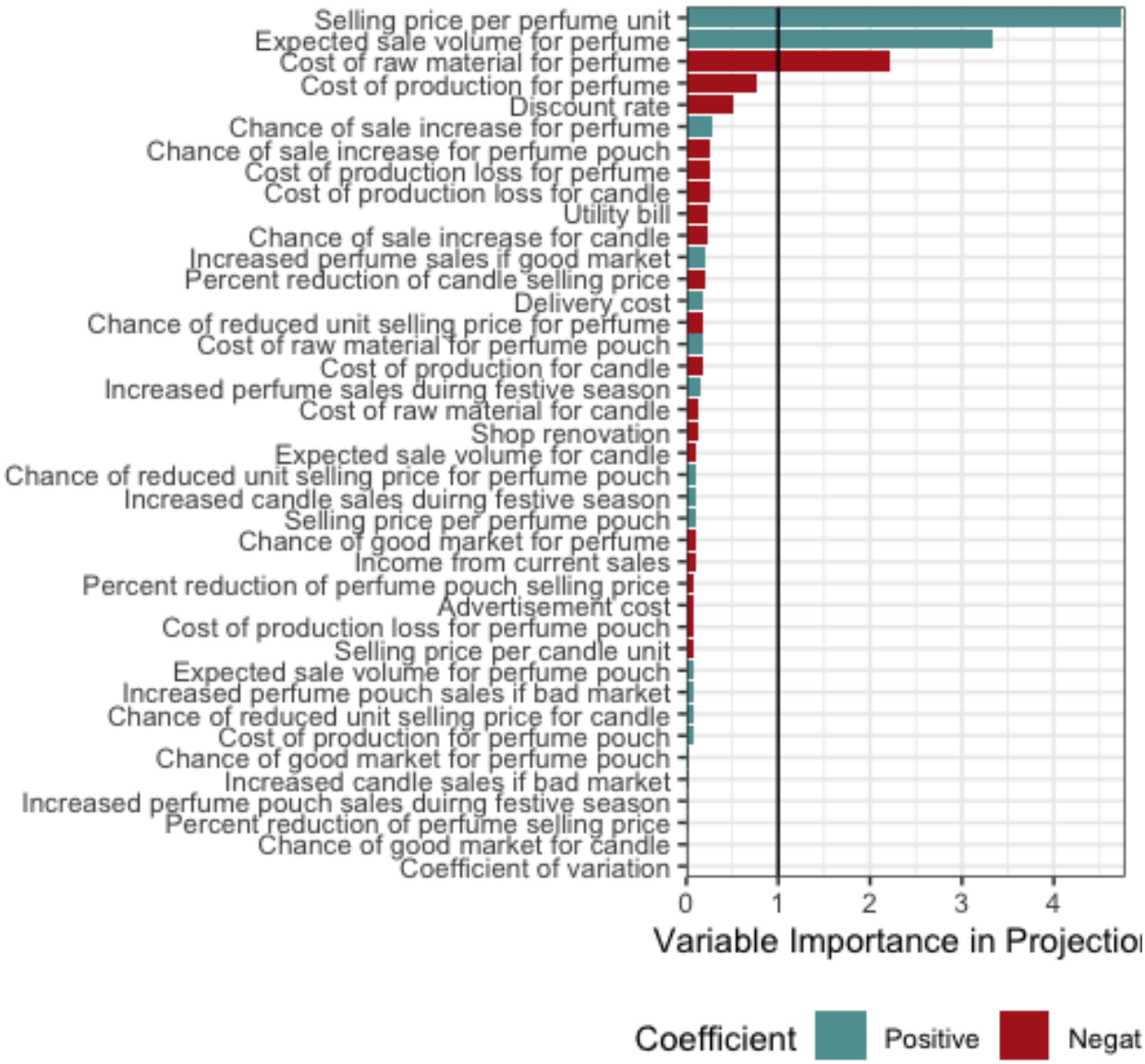

Figure 6: Fig. 6: The Variables of Importance

Discussion

Based on the analysis results, perfume is predicted to generate highest net profit among the three product options. This may be due to the higher expected revenue per perfume unit, compared to the two other products. Another reason could be the higher expected sales volumes of perfume. This is expected because the retailer is specialised in handcrafted perfumes and has already built a brand reputation.

However, the model has limitations that more comprehensive data gathering is required to generate a better forecast. The simulation was run on the yearly estimates, ignoring the possibility of monthly sale targets which can impact the annual sales. In addition, market scenarios were presented as "chance event" rather than projected trends based on surveys and previous market data, leading to possible profit reduction. Another evidence that the simulation was run on imperfect estimates is the cash flow results. It is not uncommon to have negative cash flow in the inital period of a new product launch due to the time needed for consumer acceptance for the particular product. On the contrary, the cash flows of the model were constant throught the simulation period, which is likely caused by highly inflated sale volumes. Even with the exorbitant sale volumes, the stagnant cash flows can cause major problem for the survival of the business in the long run. It can result in lack of free cash flow for the business and may disrupt operations.

Conclusion

The sale team proposed perfume as the new product addition, but the manager rejected the proposal based on the ground that the analysis was poorly done.