Profit Maximization of Flanges

Team Members

- Prabhat Gupta (001268013)
- Sagar Ghiya (001282525)
- Shloka Shah (001284708)
- Varun Ozarkar (001264099)
- Yash Dhabalia (001222881)

Master of Science in Industrial Engineering

Deterministic Operations Research (OR 6205)

Northeastern

Faculty Advisor

Prof. Md. Noor-E-Alam

Teaching Assistant

Prateek Khade

Acknowledgement

We would like to express immense gratitude to our guide Prof. Md. Noor-E-Alam for his invaluable support, encouragement, supervision and useful suggestions throughout this project work. His continuous guidance enabled us to complete our work successfully.

We also wish to express appreciation to our teaching assistant Prateek Khade for his constant cooperation and help.

Last but not the least, we are thankful and indebted to all those who directly and indirectly helped us in the completion of this project.

Table of Contents

Introduction : About the Company

G.N. ALTECH | Gujarat, India

The company manufactures High Precision Machined Components from Aluminum and Iron Castings and has got its own Casting unit and Machine shop. The Machine shop is equipped with high precision machines from MAZAK, MORI SEIKI and uses Co-ordinate Measuring Methods to maintain the quality of the product. They also implement tools like 5S, Lean etc for production. Few of the products the company manufactures are : Flanges, Housing for gear drive, Housing for electrical motors, Fluid valves and pumps.

Problem Description

Flange Department of G N Altech produces 7 different types of Flanges : Flat Faced, Lap-Joint, Blind, Slip-on, Socket-Weld, Threaded, Weld-neck. Our aim is to maximize the profit of the flanges produced, with limited resources available.

The main limitation that company is facing is the limited quantity of time available.

The 7 different types of flanges pass through various processes like : Material Handling, Casting, Heat Treatment, Quality Check-1, Machining, Quality Check-2, Anti-rust Coating and Packaging.

We collected data from the company regarding the production of flanges in a given day and the time taken for production of each flange as well as time available for each process.

Given the current state of the labor, the company estimates that for each day, they have the following time available (in minutes) :

Material Handling	120
Casting	400
Heat Treatment	380
QC-1	120
Machining	360
QC-2	180
Anti-rust Coating	240
Packaging	160

Based on the demand fluctuation, the minimum and maximum quantity required for each type of flange is as shown below :

Flange Type	Minimum	Maximum
Flat Faced	15	45
Lap Joint	15	22
Blind	15	40
Slip-on	15	45
Socket Weld	15	30
Threaded	15	25
Weld-Neck	15	35

With the data available, the final table formation is as shown below :

	Raw Material Handling	Casting	Heat Treatment	QC-1	Machining	QC-2	Anit-rust Coating	Packaging	Profit ($)
Product	Time required for production of each flange in minutes								
1	0.20	3.56	2.30	0.35	3.00	2.00	1.30	0.14	3.75
2	0.18	2.04	1.55	0.15	3.30	1.10	1.39	0.16	5.80
3	0.40	4.30	3.50	0.55	3.30	1.40	2.43	0.49	9.50
4	0.20	3.48	2.00	0.20	2.00	1.50	3.53	0.25	3.90
5	0.45	2.33	2.00	0.40	2.30	1.00	1.58	0.10	4.85
6	0.20	3.20	3.40	1.30	4.46	2.53	1.56	0.36	6.05
7	0.30	4.33	2.55	0.35	3.07	1.58	2.02	0.47	5.00
Total time availability (min)	120	400	380	120	360	180	240	160	

Mathematical Modelling

Assumptions :

- We have not considered down time and change over time as a part of the problem.
- The setup time is included in the process time.

Number of flanges to be produced :

X1 : Number of flanges of Type-1 (Flat faced flange)
X2 : Number of flanges of Type-2 (Lap joint flange)
X3 : Number of flanges of Type-3 (Blind flange)
X4 : Number of flanges of Type-4 (Slip-on flange)
X5 : Number of flanges of Type-5 (Socket weld flange)
X6 : Number of flanges of Type-6 (Threaded flange)
X7 : Number of flanges of Type-7 (Weld-neck flange)

Profit per flange in Dollars ($) :

P1 : Profit margin for flange Type-1
P2 : Profit margin for flange Type-2
P3 : Profit margin for flange Type-3
P4 : Profit margin for flange Type-4
P5 : Profit margin for flange Type-5
P6 : Profit margin for flange Type-6
P7 : Profit margin for flange Type-7

Type of processes being used during production :

1. Raw material handling
2. Casting
3. Heat treatment
4. Quality check-1
5. Machining
6. Quality check-2
7. Coating
8. Packaging

Parameters :

- Time taken for each type of flange to pass through one process
- Profit obtained on each type of flange
- Total time available for each process in a given day

Variables :

- Quantity of flanges produced in a given day (X1, X2,…,X7)

Objective Function :

Max. Profit : P1*X1 + P2*X2 + P3*X3 + P4*X4 + P5*X5 + P6*X6 + P7*X7

So,

Max. Profit : 3.75*X1 + 5.80*X2 + 9.50*X3 + 3.90*X4 + 4.85*X5 + 6.05*X6 + 5.00*X7

Subject to Constraints :

a) Time Availability Constraints :

0.20*X1 + 0.18*X2 + 10.40*X3 + 0.20*X4 + 0.45*X5 + 0.20*X6 + 0.30*X7 <= 120 ;

3.56*X1 + 2.04*X2 + 4.30*X3 + 3.48*X4 + 2.33*X5 + 3.20*X6 + 4.33*X7 <= 400 ;

2.30*X1 + 1.55*X2 + 3.50*X3 + 2.00*X4 + 2.00*X5 + 3.40*X6 + 2.55*X7 <= 380 ;

0.35*X1 + 0.15*X2 + 0.55*X3 + 0.20*X4 + 0.40*X5 + 1.30*X6 + 0.35*X7 <= 120 ;

3.00*X1 + 3.30*X2 + 3.30*X3 + 2.00*X4 + 2.30*X5 + 4.46*X6 + 3.07*X7 <= 360 ;

2.00*X1 + 1.10*X2 + 1.40*X3 + 1.50*X4 + 1.00*X5 + 2.53*X6 + 1.58*X7 <= 180 ;

1.30*X1 + 1.39*X2 + 2.43*X3 + 3.53*X4 + 1.58*X5 + 1.56*X6 + 2.02*X7 <= 240 ;

0.14*X1 + 0.16*X2 + 0.49*X3 + 0.25*X4 + 0.10*X5 + 0.36*X6 + 0.47*X7 <= 160 ;

b) Demand Fluctuation Constraints :

15 <= X1 <= 45;
15 <= X2 <= 22;
15 <= X3 <= 40;
15 <= X4 <= 45;
15 <= X5 <= 30;
15 <= X6 <= 25;
15 <= X7 <= 35;

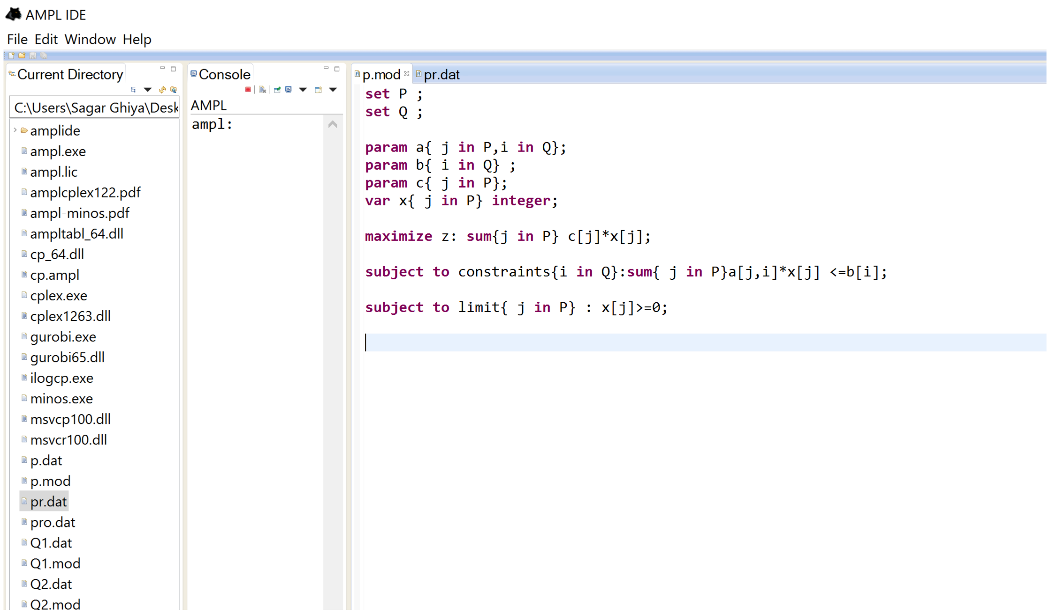
X1, X2, X3, X4, X5, X6, X7 are all integers.

PC Description

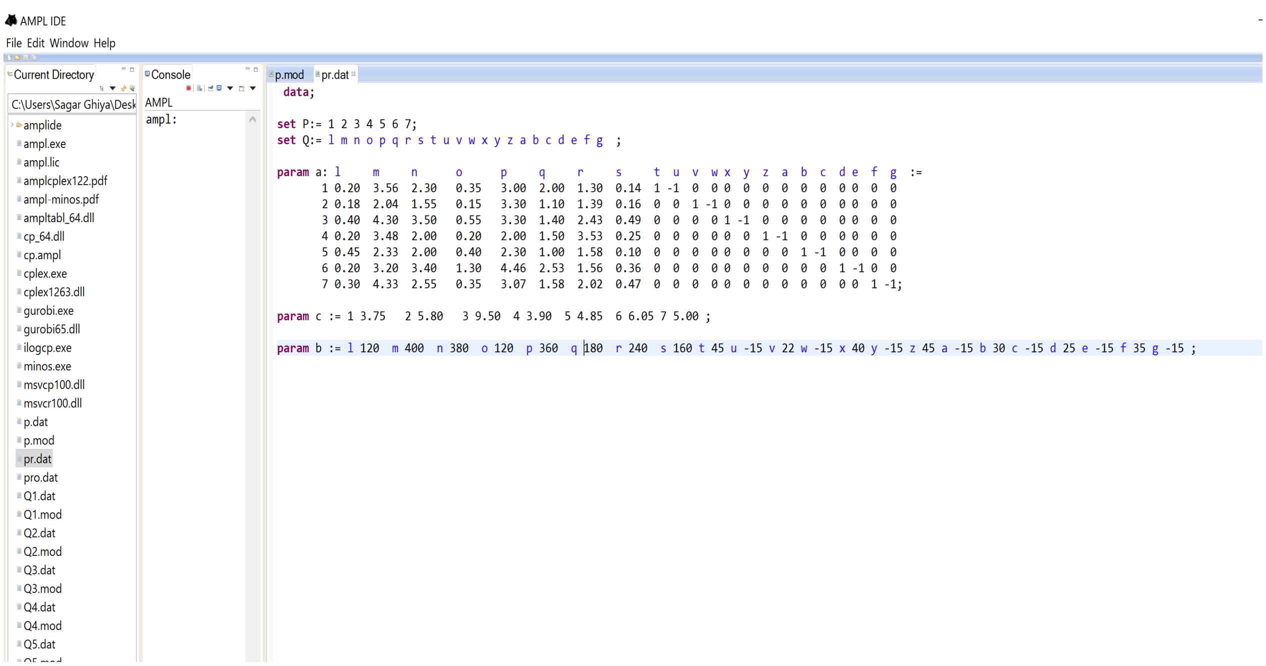
RAM : 16 GB
Processor : 6 GEN Intel i7 (3.6 GHz)
Memory : 1 TB HDD / 128 GB SSD
OS : Windows 10, 64 bit, x64 based processor

AMPL Implementation

Model File :

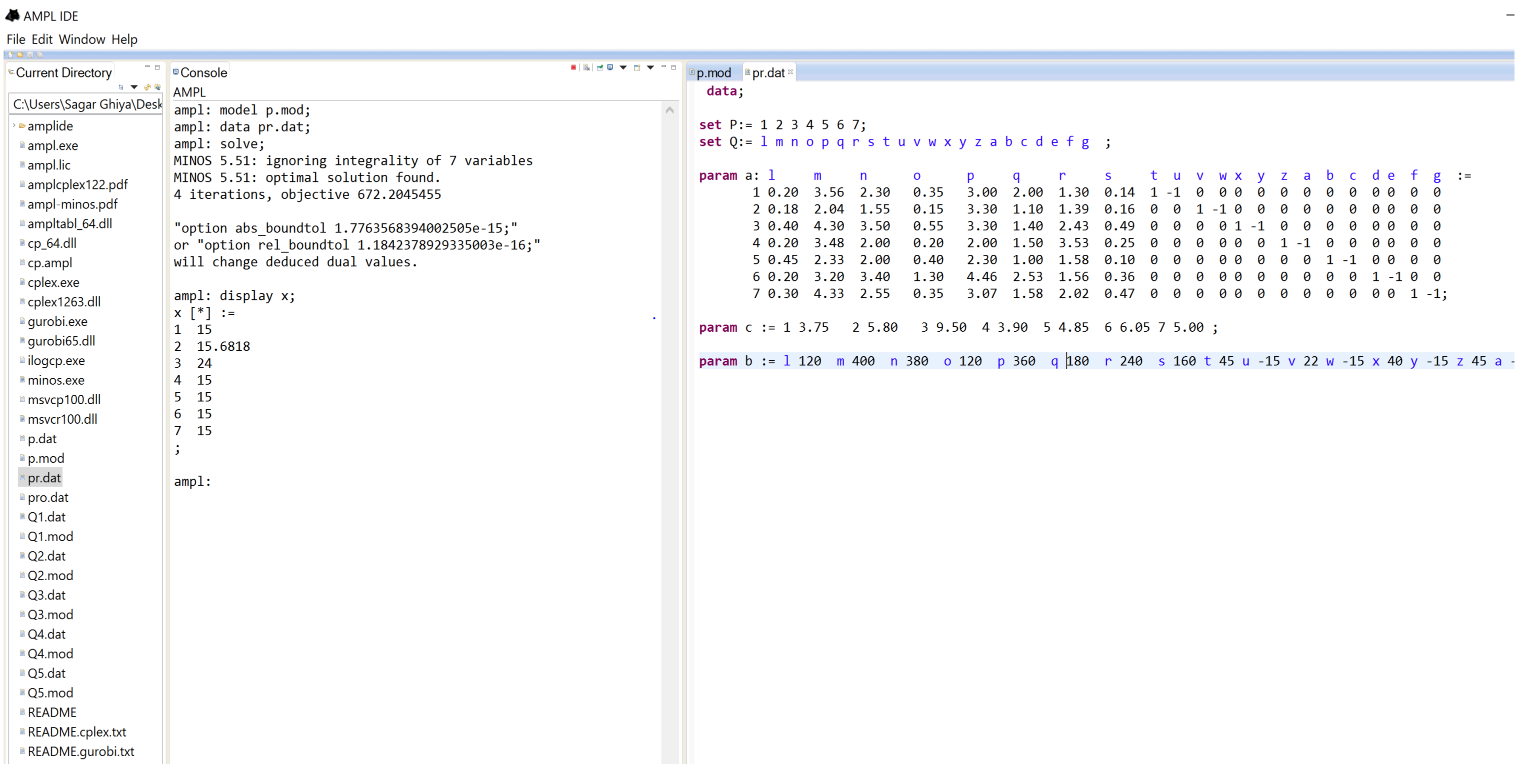


Data File :



AMPL Execution

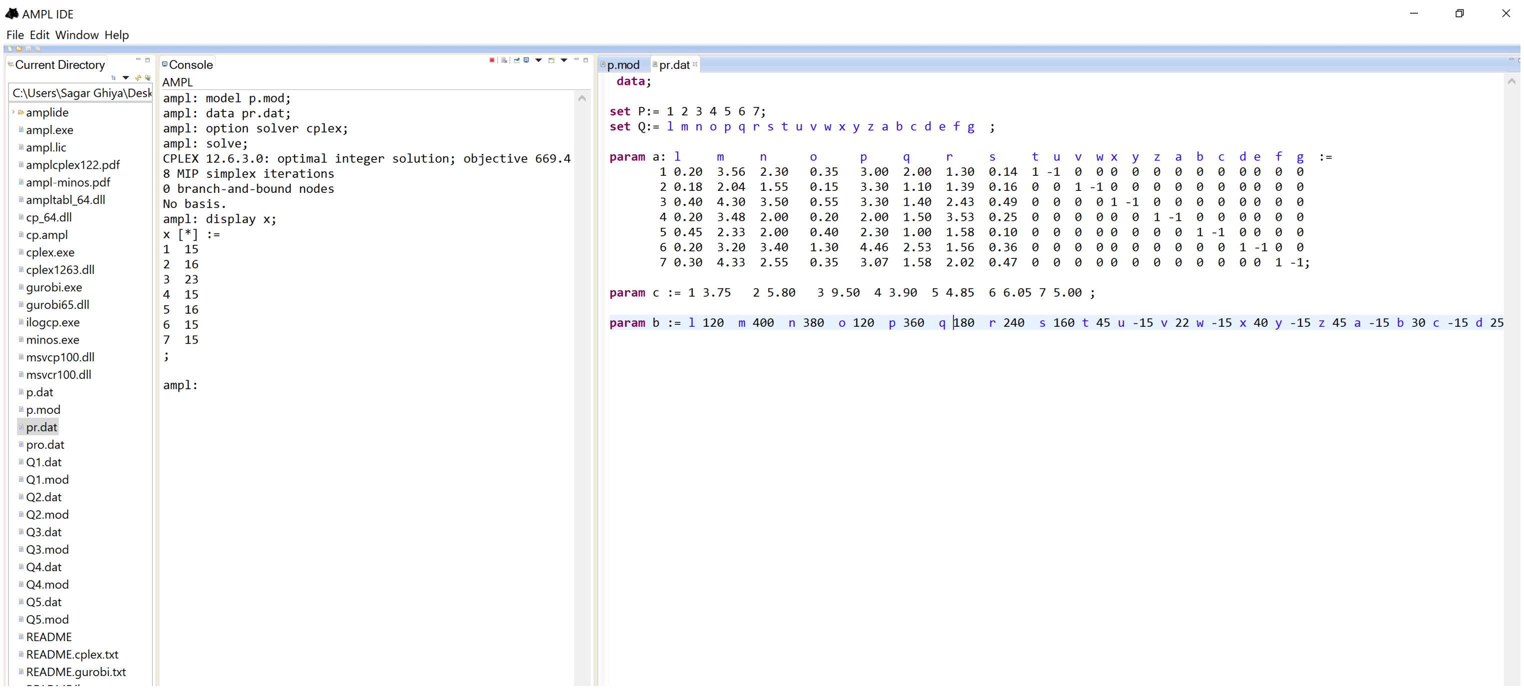
a) Using MINOS :



Even after putting Integer constraint in the model file, we get non-integer values.

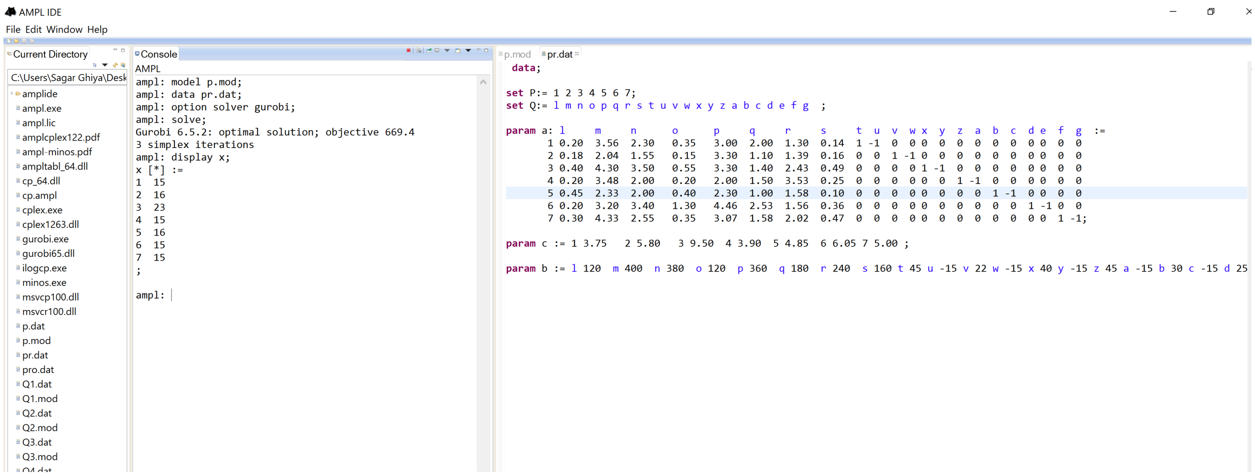
This is because, MINOS solver doesn't solve integer programs.

b) Using CPLEX :



Now, we have used CPLEX solver which gives us integer values.

c) Using GUROBI :

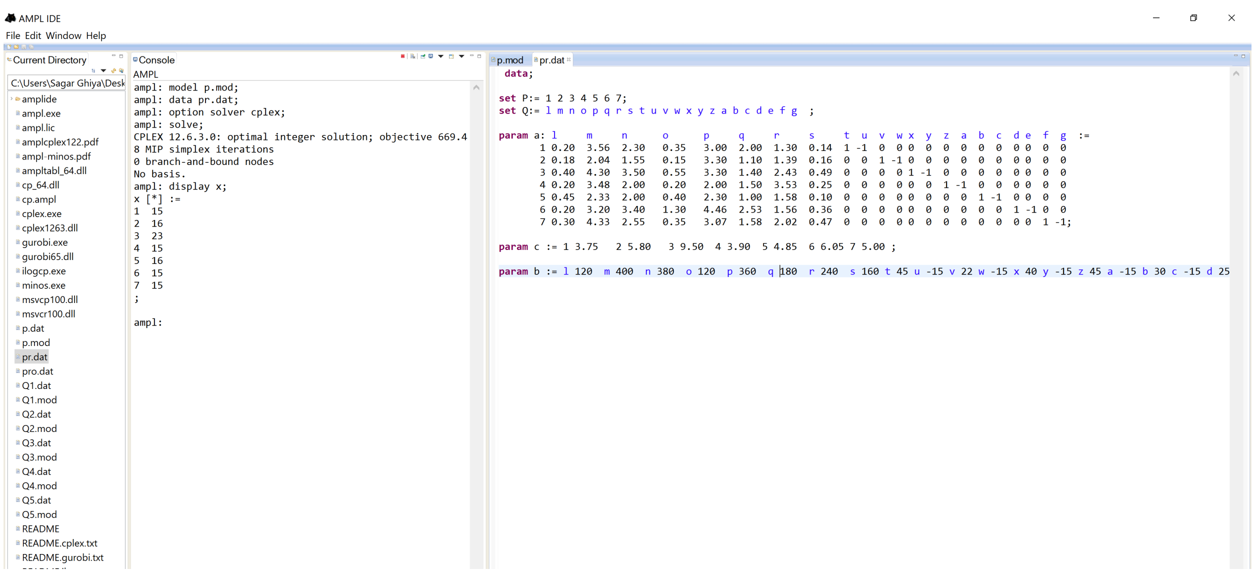


- Both CPLEX and GUROBI give us same solution.
- It is claimed that GUROBI is faster than CPLEX.
- Also, GUROBI is better at finding Integer feasible solutions.
- But since our data-set is not that large it doesn't matter whether we use CPLEX or GUROBI.
- Both the solvers take same time to return the solution.

Sensitivity Analysis

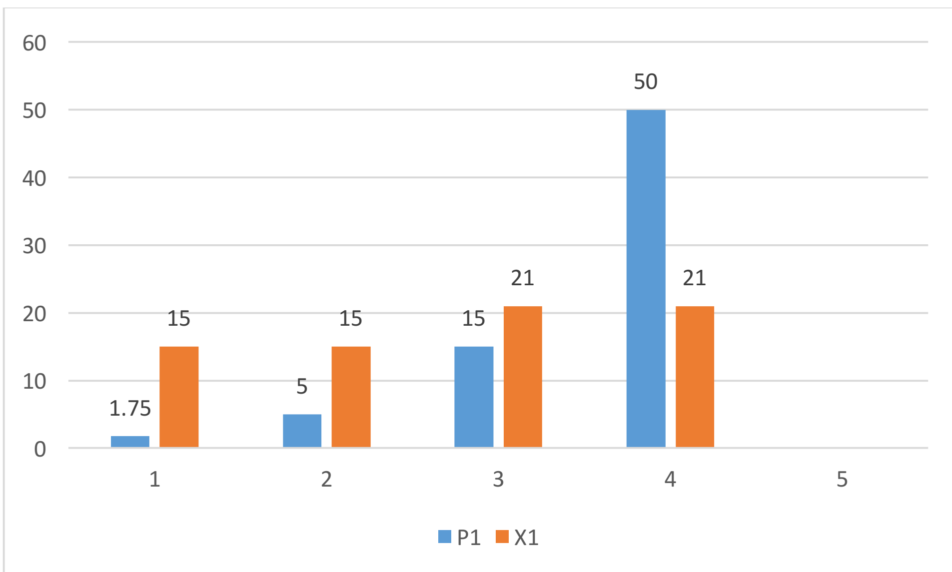
- **Sensitivity Analysis** is a technique used to determine how different values of an independent variable impact a particular dependent variable under a given set of assumptions.
- We have changed the values of different parameters such as profit, time required for each flange in each process and total time available for different processes.

Original Execution



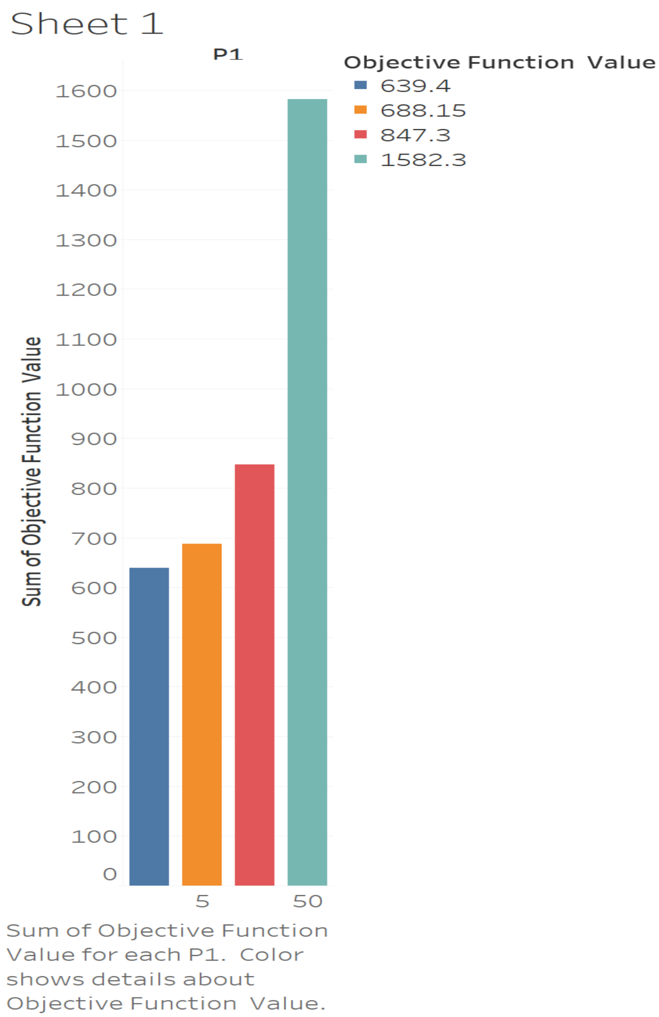
Case 1 : Change in Profit

Objective Function Value	P1	X1	X2	X3	X4	X5	X6	X7
639.4	1.75	15	16	23	15	16	15	15
688.15	5	15	16	23	15	16	15	15
847.3	15	21	16	15	15	15	15	15
1582.3	50	21	16	15	15	15	15	15



- The above graph shows the relation between profit and quantities of type 1 flange.
- With the increase in profit from \$ 1.75 to \$5, the number of flanges produced remains same. This is because other flanges have more profit than type 1 flange. So more quantities of those flanges are produced.
- However, when profit is changed to \$15(maximum of all), the number of flanges produced for X1 becomes 21 in order to increase maximum value.

- Now even if we keep on increasing value of P1, the quantities of type1 flange cannot increase. For it to increase, quantity of other flanges should decrease to satisfy the time constraint. But other flange quantities are already at their minimum values.

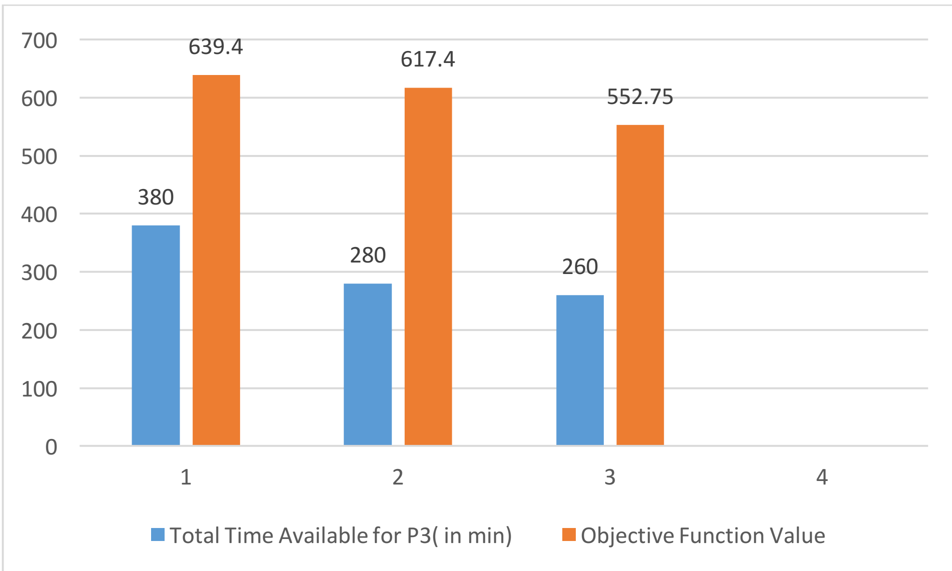


S1: P1 vs Objective function Value

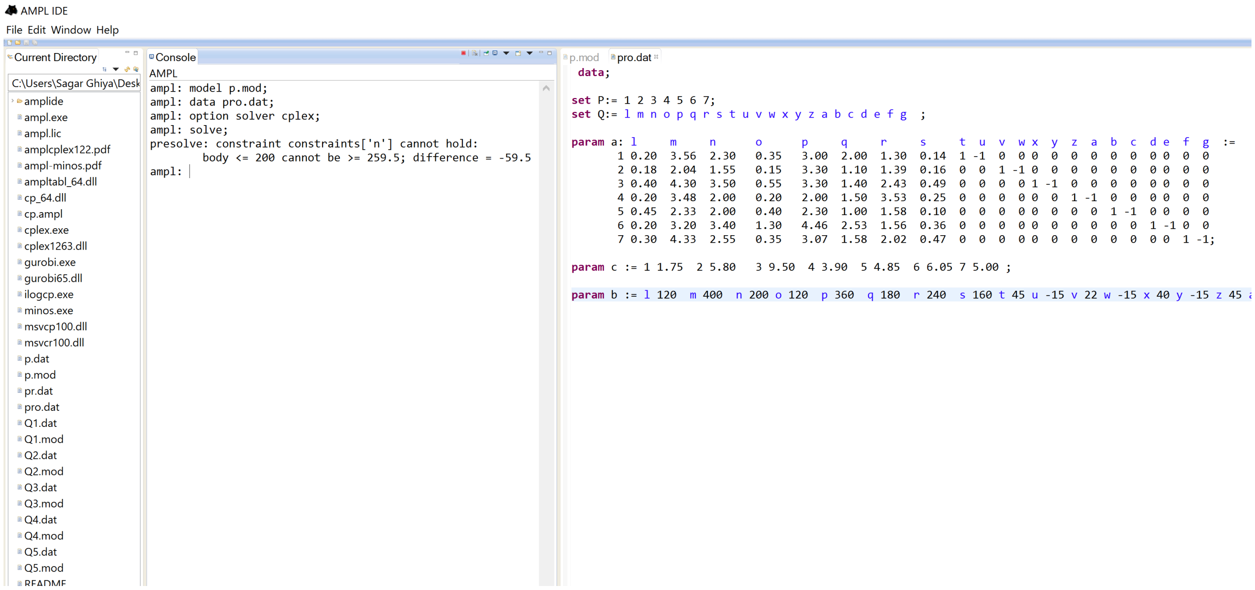
- With the increase in profit, objective function value increases.

Case 2 : Change in total time available for Flange Type 1

Total Time Available for P3(in min)	Objective Function Value	X3	P3
380	639.4	23	9.5
280	617.4	16	9.5
260	552.75	15	9.5

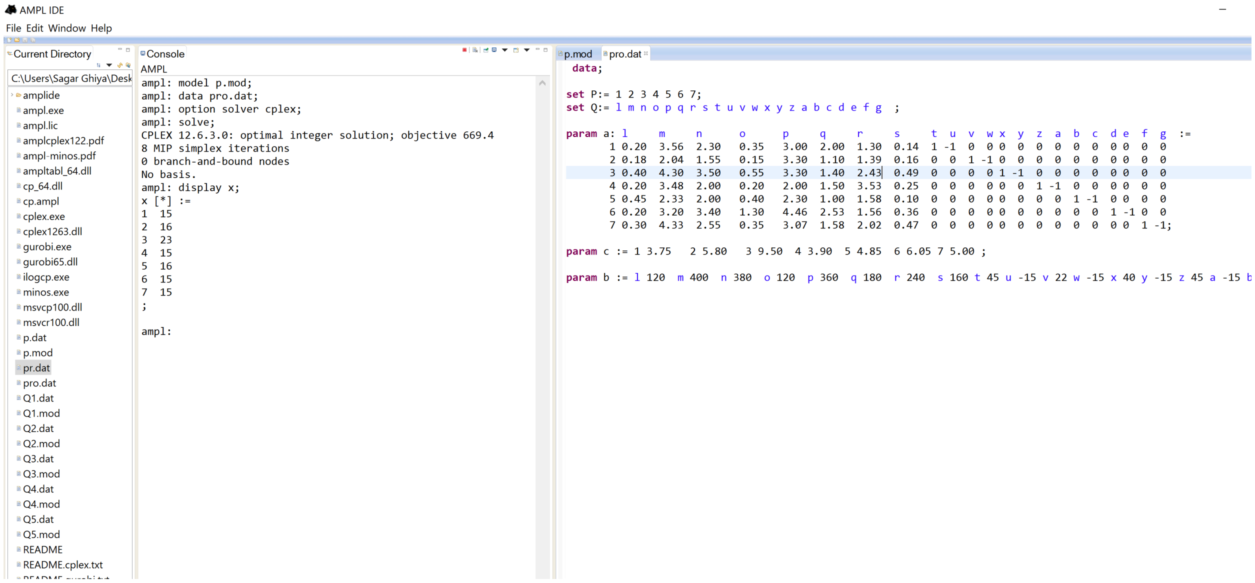


- With the decrease in total time available for process 3, the value of objective function decreases.
- This is because the time resource has been made shorter, so the quantities have to be cut short in order to satisfy the time available constraint. As seen from the table, value of X3 decreases.

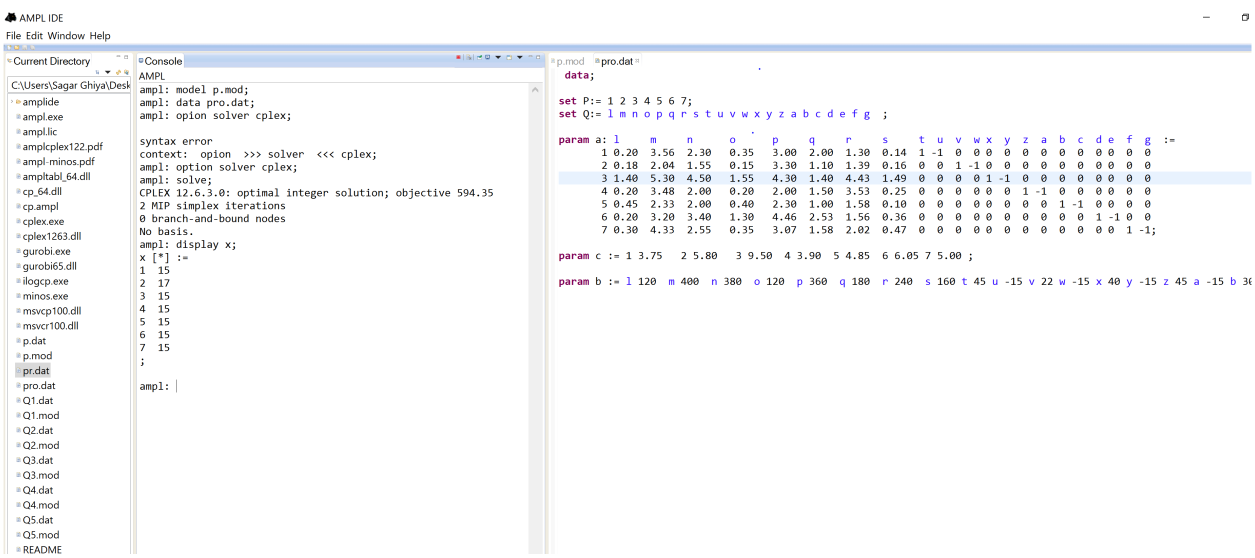


- If we decrease the total time available further, we get an infeasible solution.
- This is because the total time constraint is violated, even if all the products take their minimum values.

Case 3 : Change in time consumed by Flange in Process 3 (Heat Treatment)

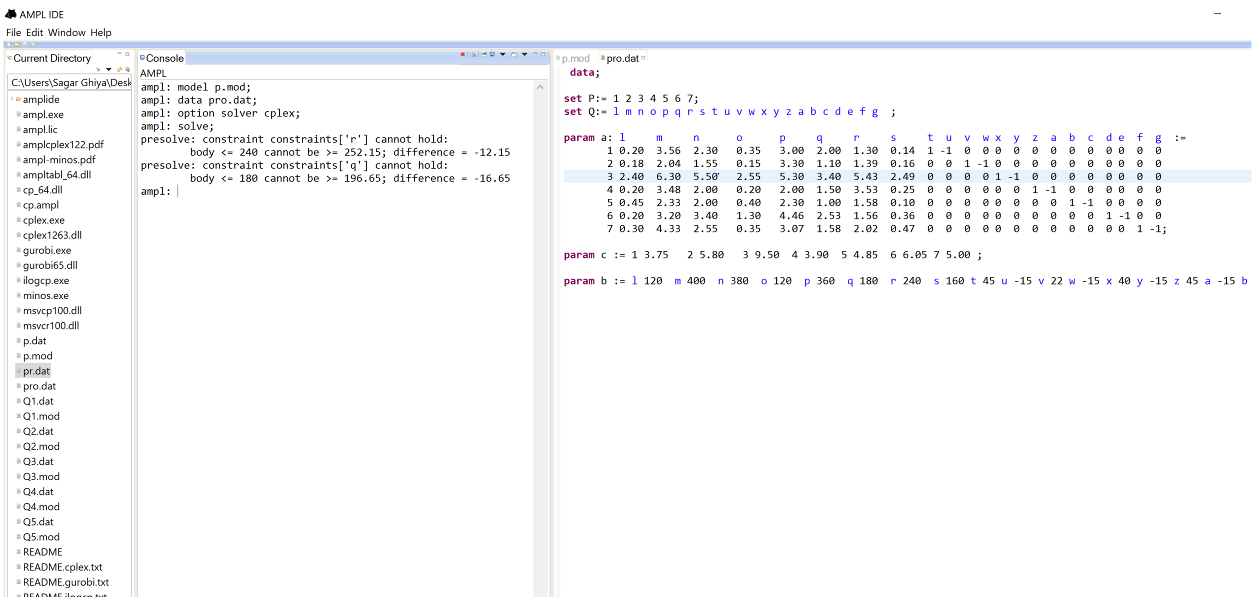


- This is the normal condition which displays our original solution with value of objective function and decision variables.



- Let us consider a situation when time for process 3 increases by 1 min for each type of flange due to some problem.

- Due to this, the number of quantities produced decreases in order to satisfy the time available constraint.
- Thus the objective function value also decreases.
- Other products maintain their minimum value.



- If we further increase the time by 2 min from our original problem(as highlighted above), we observe that the solution is infeasible.
- This is because, even if all the products take their minimum value, the time constraint will not be satisfied.

Conclusion

After implementing the entire project in AMPL and performing sensitivity analysis, we make following suggestions for company G.N. Altech to increase its profits:-

- ✓ We observed that none of the products manufactured have reached their maximum value, that is, product manufactured of each type has never meet its maximum demand.
- ✓ This is because of the limitation of time resource. So if company can increase the time each machine works, profit will increase as quantities produced will increase.
- ✓ Also, the company must work on increasing the efficiency of their machines. More efficient machines will take less time to manufacture each flange and hence profit will increase.
- ✓ One obvious conclusion is that the company should focus more on producing products which have higher profit margin.

Summary

- Problem Description
- Mathematical modeling
- AMPL Execution
- Sensitivity Analysis
- Graphical representation of sensitivity analysis

Bibliography

- The AMPL Book
- Operations Research, Applications and Algorithms (4th edition)
- G.N.Altech Company Website (www.gn-altech.com)
- www.wikipedia.com