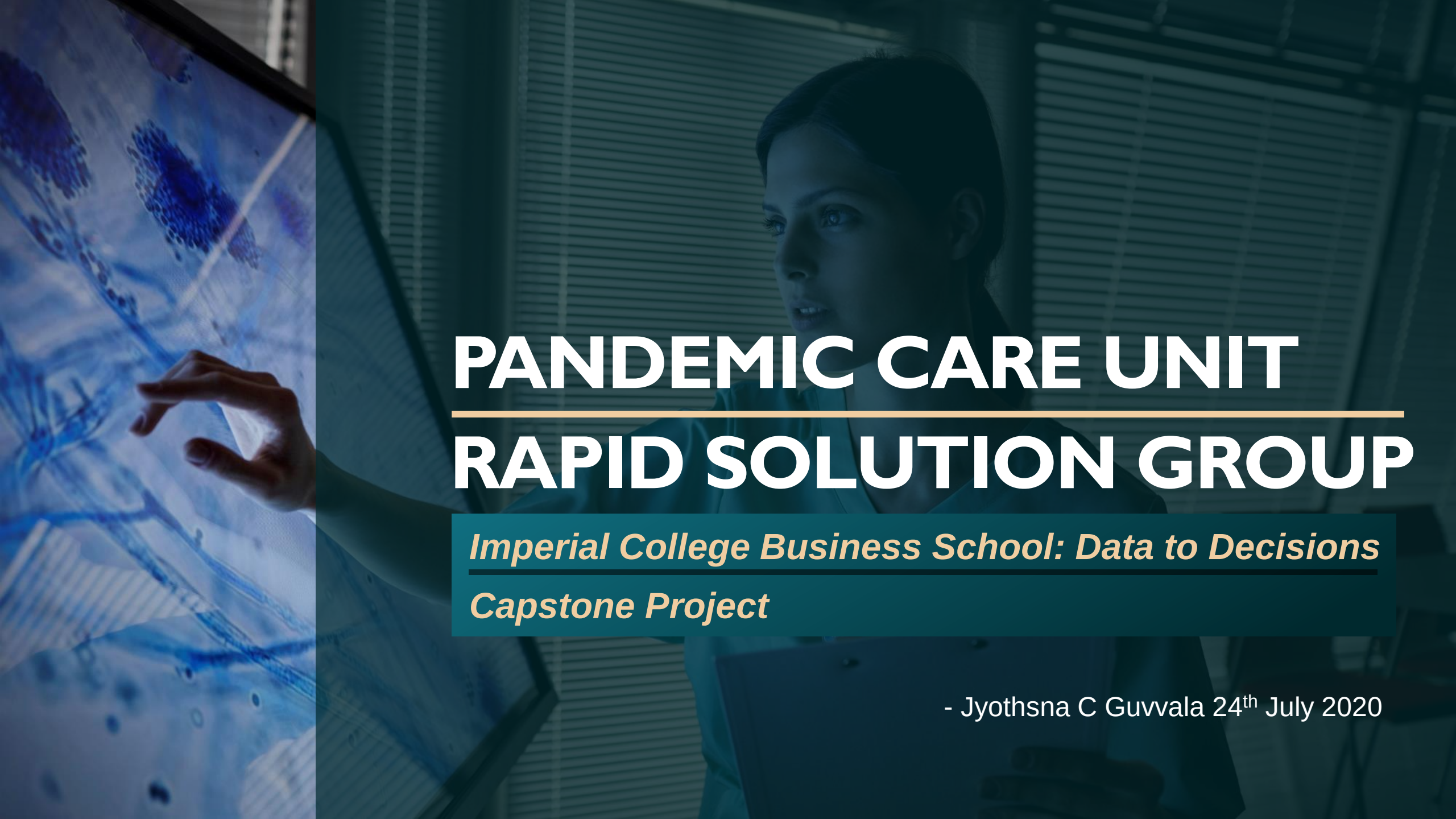


PANDEMIC CARE UNIT

RAPID SOLUTION GROUP

Imperial College Business School: Data to Decisions

Capstone Project

- Jyothsna C Guvvala 24th July 2020

OUR MISSION

We aim to become the leading provider of cost effective, scalable, clinically fit and portable mechanical ventilator units across the UK during the Covid-19 pandemic.

INDUSTRY OUTLOOK

14000+

U.K. Gov calls quick action for additional ventilators during pandemic*

£ 454M

U.K. Gov ventilator challenge program budget**

25 - 30%

Our estimated Per unit profit Margin

4000 - 6000

Our capacity in units per week

40%

Good PR ***

Success

*https://www.gov.uk/government/news/ventilator-challenge-hailed-a-success-as-uk-production-finishes
**https://www.nao.org.uk/wp-content/uploads/2020/05/Overview-of-the-UK-governments-response-to-the-COVID-19-pandemic.pdf
*** predicted

THE MARKET

CUSTOMER SEGMENTATION

Pandemic Response Hubs

Hospitals and Clinics

Home Care

Ambulatory Care Centers

Emergency Medical Services

Airplanes

Defense Services

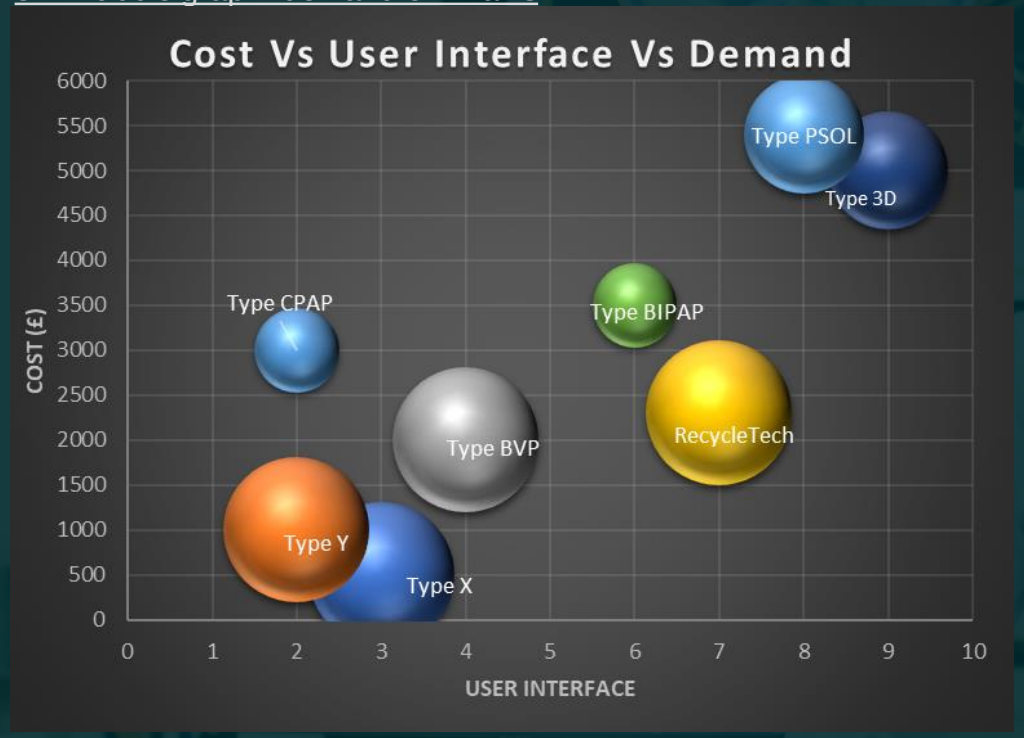
- Ventilators are standard equipment in intensive care units and emergency departments
- Respiratory ventilators market was mature and competitive with annual growth reliant on replacements prior to pandemic
- International players control approximately 80% of the ventilators market across the UK, with smaller manufacturers making up the remainder

- https://medical-technology.nridigital.com/medical_technology_apr20/can_car_manufacturers_help_with_the_need_for_ventilators_in_the_uk
- https://www.marketsandmarkets.com/Market-Reports/ventilators-market-11018337.html
- https://www.hamilton-medical.com/en_GB/Products/Mechanical-ventilators/HAMILTON-T1.html?gclid=EAIaIQobChMIkr7Cqanb6gIV5IBQBh07KADMEAAYASAAEgIUbfD_BwE

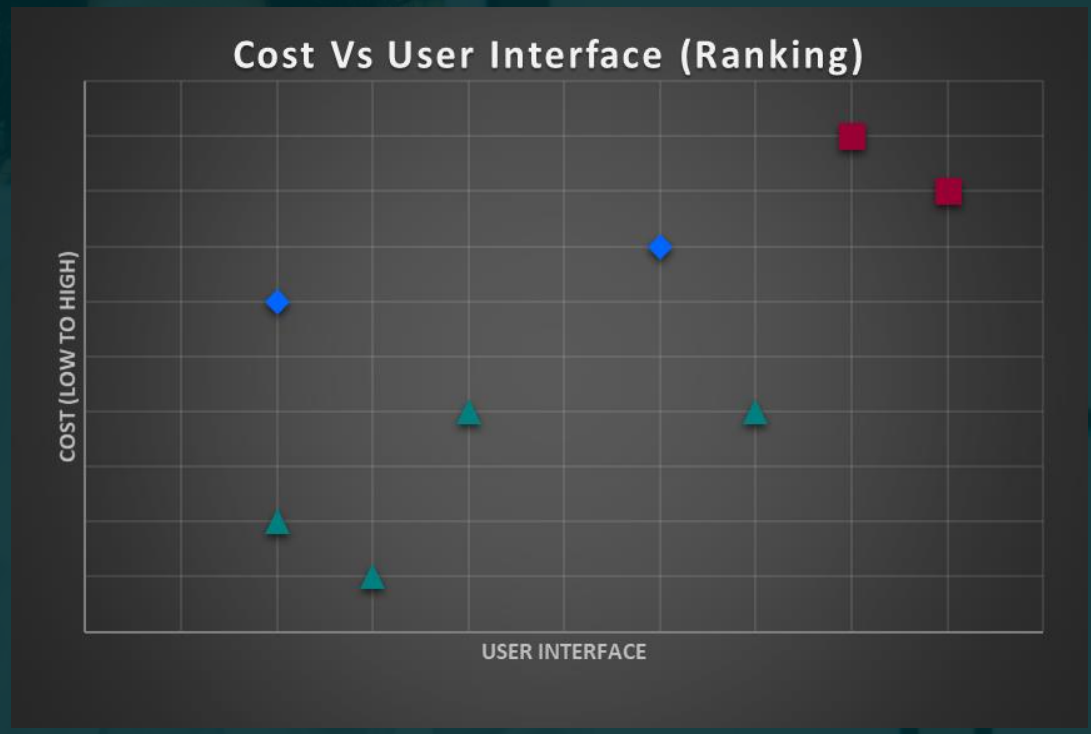
VISUALS

GRAPHS (MOCK DATA)

3 D Bubble graph- demand on Z-axis



2 D scatter plot , categorical data on x- axis and y-axis



•It is feasible to produce and sell both type of ventilators. For optimal profit, 6000 Type X and 1400 Type Y ventilators is best model

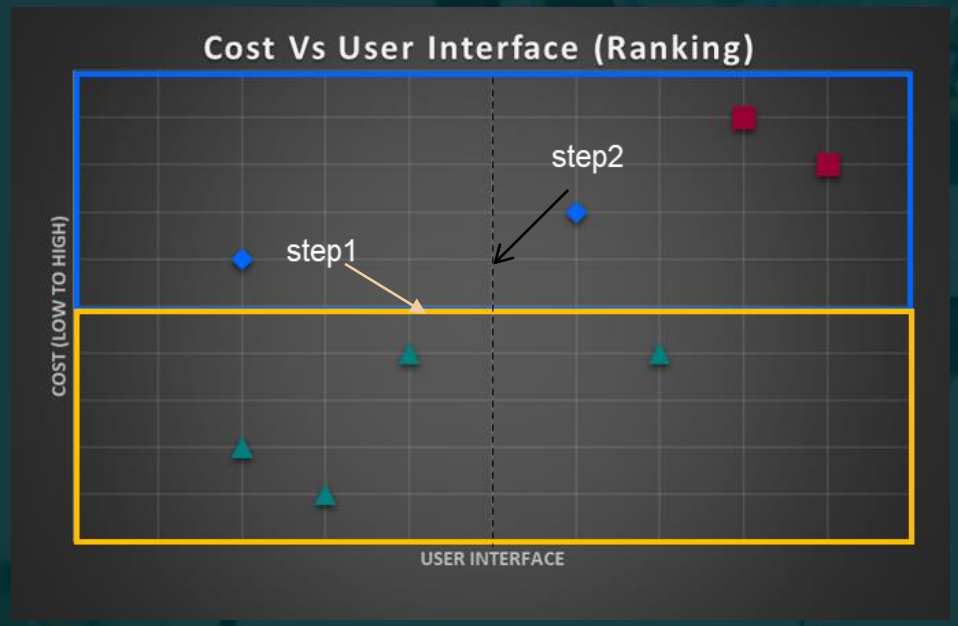
•Individually, ventilator Type X is more profitable compared to Type Y. Week profit on Type X is 6000*25 = £150000 and on Type Y is 4000*30 = £ 120000 (Ps: this is not within all the constraints in the capstone. Just to make the point here)

•Slack of 18.57 hours in Type Y hours indicate scope to produce more type y ventilators provided constraint on person-hours is addressed

VISUALS

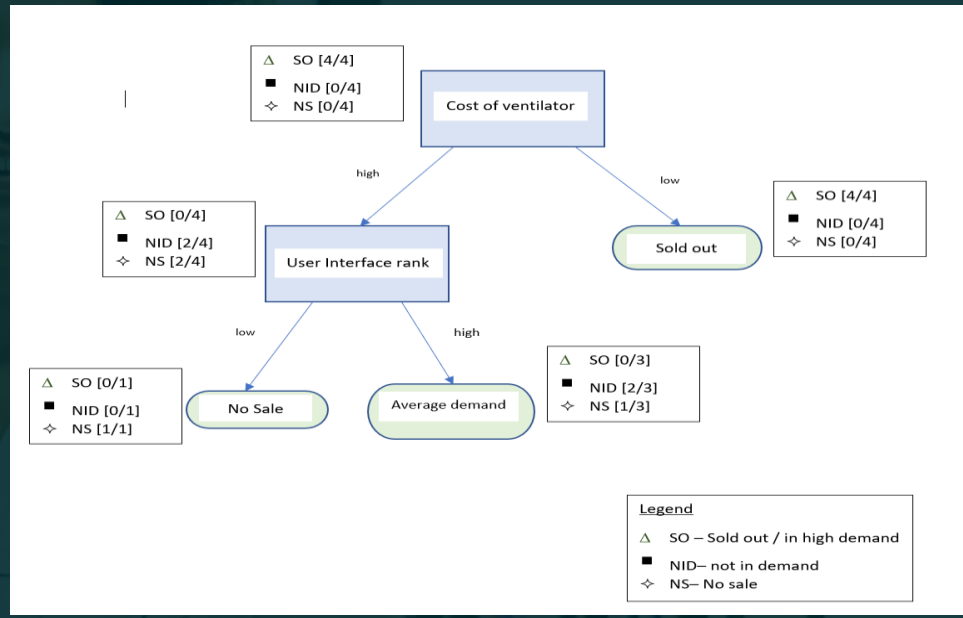
GRAPHS (MOCK DATA)

Classification Visual:



Medical Ventilators	Demand	User Interface	Cost (Low to High)		Cost	Low	<=	£ 2,500
Type X	H	3	1			High	>	£ 2,500
Type Y	H	2	2					
Type BVP	H	4	4		User Interface	Low	<=	5
RecycleTech	H	7	4			High	>	5
Type CPAP	L	2	6					
Type BIPAP	L	6	7		Demand	Low	Medium	High
Type 3D	M	9	8			3	2	3
Type PSOL	M	8	9					

Classification tree:



Prediction:

Cheap ventilators are in high demand (pandemic)

Split Step: 1

2

Horizontal	cost	4/4	better purity	Vertical	User Interface	2/3
Vertical	User Interface	1/4	more impure			

MACHINE LEARNING TECHNIQUE

Classification - Data to decisions

Classification is a supervised learning Machine Learning technique used to categorize a set of data into classes. It can handle either a binary classification problem or a multi-class problem. It is an algorithm that uses one or more independent variables to determine an outcome. The outcome is measured with a dichotomous variable i.e. it will have only two possible outcomes.

Advantages

Like an if-then statement, it is simple to understand and interpret. Yet, it is also a powerful technique that could span to complex classification trees

It is useful in understanding how a set of independent variables affect the outcome of the dependent variable

Disadvantages

The main disadvantage of the logistic regression algorithm is that it only works when the predicted variable is binary

It assumes that the data is free of missing values and assumes that the predictors are independent of each other

Classification trees are a type of decision trees. Decision trees help in arriving at a result by logically splitting a data set into subgroups

Decision trees can be used to visually and explicitly represent decision making and decisions

Trees can also be displayed graphically in a way that is easy for non-experts to interpret

Able to handle both numerical and categorical data, unlike other relation rules (K-nearest) used only with nominal variables

They require little data manipulation

Decision-trees can span to very complex trees

OUR VENTILATOR OPTIONS

Insights

	Type X	Type Y	
Units per hour	200	140	
Max units per week	8000	5600	
weekly production limit	6000	4000	
Max hours	30	28.57	
Profit per unit	£ 25	£ 30	
Decision variables			
Typex(hours)	Typey(hours)		
30	10		
Objective Function			
Maxime Profit			
192000			
Constraints	Actual		Limit
typexhours	30	<=	30
typeyhours	10	<=	28.57
weekly hours	40	<=	40

AMPL

```
ampl: model ventilators.mod;
ampl: solve;
MINOS 5.51: optimal solution found.
2 iterations, objective 192000
ampl: display x, y, typex.slack, typey.slack, hours.slack;
x = 30
y = 10
typex.slack = 0
typey.slack = 18.57
hours.slack = 0

ampl:
```

```
# define variables

var x >=0;
var y >=0;

# objective function

maximize profit: 200 *  x * 25 + 140 * y  * 30;

# constraints

#subject to typex: x <= 6000;
#subject to typey: y <= 4000;
#max hours on typex=6000/200=30hrs
#max hours on typey=4000/140=28.57hrs
subject to typex: x <= 30;
subject to typey: y <= 28.57;
subject to hours: x+y <= 40;
```

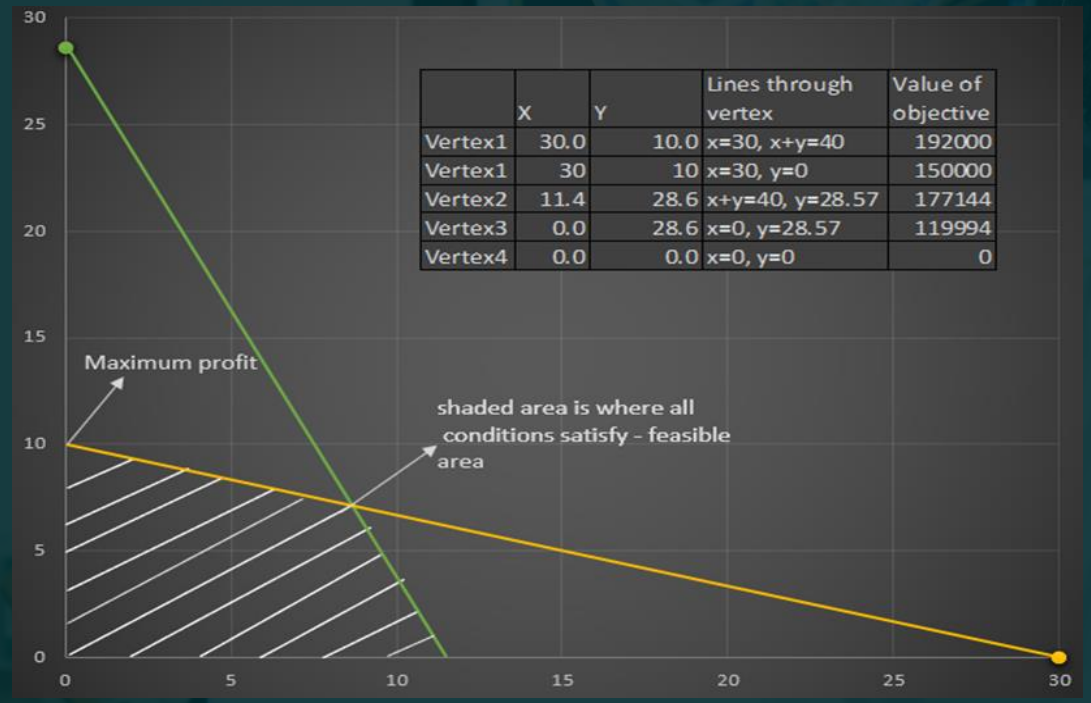
* £ instead of $ to match with slide3

- Hypothesis: A quick look at the data shows Type X units are faster to produce than Type Y. Type Y has higher per unit in comparison to Type X. Both have equal available hours per week. Looking at the data, I assume Type X contribute higher to the profit
  - "If the number of units per hours is higher then the profit is maximised" given all products are given equal production time
  - From results, the hypothesis is proven correct in the results from 'solver'
- It is feasible to produce and sell both type of ventilators. The model for optimal profit is 6000 Type X and 1400 Type Y ventilator units per week
- In the scenario, ventilator Type X contributes more to the profit. Per week profit on Type X is £150000 and on Type Y is £42000
- Slack of 18.57 hours in Type Y hours indicate available capacity Whereas capacity on Type X is stretched which could be a constraint in an event of machine break down or other resource issues.

OUR VENTILATOR OPTIONS

Insights

Optimization graph in Excel



	X	Y	Lines through vertex	Value of objective
Vertex1	30.0	10.0	x=30, x+y=40	192000
Vertex1	30	10	x=30, y=0	150000
Vertex2	11.4	28.6	x+y=40, y=28.57	177144
Vertex3	0.0	28.6	x=0, y=28.57	119994
Vertex4	0.0	0.0	x=0, y=0	0

2 D scallet plot , categorical data on x- axia and y-axis

```
In [1]: from pulp import *

In [2]: prob = LpProblem("Ventilators", LpMaximize) #Create a LP max problem
        x = LpVariable("x", lowBound=0, cat='Integer') # Create a variable x >= 0
        y = LpVariable("y", lowBound=0, cat ='Integer') # Create a variable y >= 0
        prob += 200 * x * 25 + 140 * y * 30 # Objective function
        prob += x <= 30 # Max hours on x per week
        prob += y <= 28.57 # Max hours on y per week
        prob += x + y <= 40 # Hours per week
        prob

        status=prob.solve()
        LpStatus[status]

        value(x), value(y), value(prob.objective)

Out[2]: (30.0, 10.0, 192000.0)
```

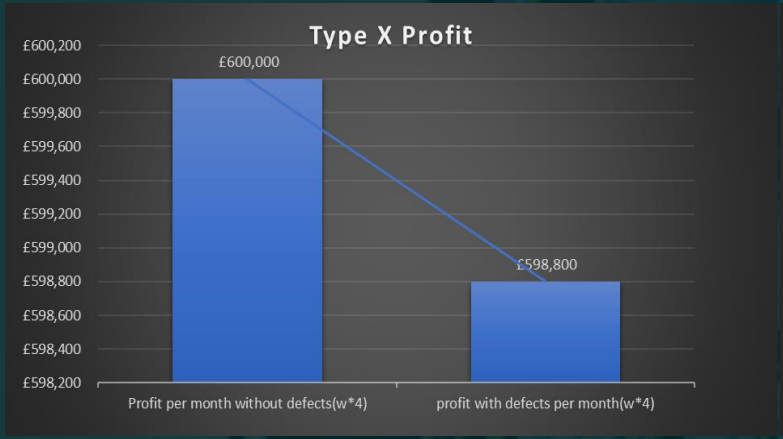
•MS Excel is familiar to many and is relatively straightforward in producing simple graphs. Python would need good knowledge to exploit full benefit it offers, requires coding skills. It would be most suitable for much complex problems among the two.

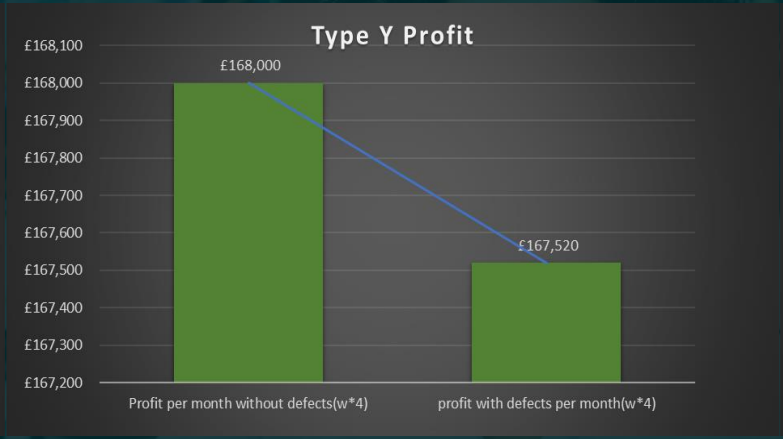
•AMPL is ready off-the-shelve tool with minimal coding or manipulation. It would be quick and easy to master the skills

•Above, I find, the first best approach would be to write develop logic on a piece of paper i.e. deciding decision variables, writing an objective function and formulating constraints

OUR VENTILATOR OPTIONS (WITH DEFECTS)

Insights





weekly production limit	6000	4000	
Average defect rate per week	0.20%	0.10%	
defects	12	4	
Data for analysis	Type X Profit	Type Y Profit	Totals
Profit per week without defects	£ 150,000	£ 42,000	£ 192,000
Profit per month without defects(w*4)	£ 600,000	£ 168,000	£ 768,000
profit with defects per week	£ 149,700	£ 41,880	£ 191,580
profit with defects per month(w*4)	£ 598,800	£ 167,520	£ 766,320
Decrese in profit per week due to defects	£ 300	£ 120	£ 420
Decrese in profit per month due to defects(w*4)	£ 1,200	£ 480	£ 1,680

- One key element, defect rate was forgotten in profit prediction. Raising questions on validity on the numbers
- Assuming an average weekly defect rate of 0.2% on Type X and 0.1% on Type Y
- Direct decline in weekly per unit profit. Decline of £ 300 on Type X and £480 on Type Y per week.
- Ventilators are highly accurate devices due to the critical care they provide. The model might no pass-through regulations with defect rate >0.0001%. This need to be checked earlier on
- If the defects continues into production phase, financial implications mean cutting in up to 75% of per unit profit. These are in logistics (20%) , SLA refunds(5%), liabilities (50%) (Made up data)

OPTIMIZATION PROJECT

Conclusions, anticipated results

While the model provides a method to achieve optimal profit, assumption are to be verified :

Assumptions:

- How sure is the profit per unit figure , how is that arrived at
- Does the per unit profit include the operational and business overhead. If not , the project would not be a viable option!
- Do we have expertise to work 40 hours a week – to full capacity
- Would we gain necessary approvals (MHRDA, ISO , European) regulations pass both , any of the models? And quickly enough
- Can we form right level of tie-ups with the industry experts
- Can we source the parts quickly and for break-fix of required
- What kind of support process would be put in place when we move to production stage
- Can we look at providing expertise, support to industry experts (medical manufacturers) instead of competing
- Could we do this support at any stage if failing at prototyping, approval to put good use of the energy invested thus far?

- Some of these questions are answered in following slide

ORGANIZATIONAL CHALLENGES

Risks and Rewards

Risk

- Entering highly regulated market with vigorous approval process and high liabilities would be a high Risk

  One approach would be to adapt an existing off-patent models for quick prototyping.

  Ask Government help to take up liabilities

- Resistance to organizational changes could be a deciding factor

  Clear communication on organization goal and explaining the opportunity to serve the community could motivate employees to contribute

Reward

- Quick to develop core expertise, setup a new ecosystem is an opportunity in these challenging times

  A tie-up with industry experts by forming a consortium, lending expertise where necessary would be a good contribution to the society

MAJOR COMPETITORS *

Premier Medical Devices

Started business in 1958. Mainly operate in creating medical equipment in the U.K. market. Have patented and the state of art ventilator technology. Very competitive on pricing. Main target market is geared towards High tech devices and specializes in dental implants and surgeries

Global MedDev, Inc.

Started business in 1920. Offer innovative technology and services. Pricing standard to market. Excellent global reach and commanding market share. They are running to full capacity and could struggle to cope with new challenges

Motors R Us

Established U.S. car manufactures with a diverse business and global reach tied-up in U.K. businesses. Priority would be to serve to the demand in the native country

* (Mock information , looking at a template)

THANK YOU

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