Budgeting using Activity Based Funding data

UnitingCare Ageing

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Acknowledgements

Many thanks to Andrew Ng at Stanford University whose work in machine learning influenced this presentation.

Further details at CS229 homepage at www.stanford.edu

Purpose

- Outline a methodology using simple statistics to prepare a budget for an inpatient ward.
- This method can be extended to other clinical areas.

4 steps in product costing

1. Manipulate GL costs to reflect products to be costed.
2. Apportion costs in overhead cost centres to final cost centres
3. Partition final cost centres into product categories
4. Within each product category, allocate cost to end-classes

Sample data

ALOS	Cost	Allied	Imag	Path	Pharm	WardMec	WardNurs	WardSupp
3.35	5969.90	124.32	127.23	109.06	124.96	781.55	1042.53	424.20
3.71	2569.56	83.49	32.77	65.12	5.63	90.91	737.75	152.65
5.46	4594.49	64.62	89.40	48.11	33.37	115.17	2076.32	524.11
3.70	5690.03	163.03	408.06	69.34	140.93	664.33	1233.96	681.66
4.26	7328.59	173.60	200.54	141.90	200.34	850.78	1596.79	1008.95
3.64	9462.35	394.87	331.20	134.96	183.04	958.66	1439.62	732.81
2.69	4038.35	193.15	57.73	66.42	89.99	368.81	768.26	249.93
2.44	3075.10	9.96	0.51	1.88	53.62	122.18	1503.25	533.52
5.78	10363.74	249.09	0.37	66.25	119.12	233.78	4337.64	2018.94
3.64	6072.40	12.98	84.19	55.05	97.86	432.82	2363.65	1039.57
7.05	6839.81	7.94	12.38	126.27	50.64	545.45	2081.84	726.82
4.57	5993.04	416.89	192.79	214.32	191.91	892.21	1810.83	598.23

Proof of concept
using linear regression with one variable

Linear regression

- Models the relationship between x and y by finding a function y = h(x) that is a close fit to the data.
- Assumptions x is not random and y is a function of x plus some random noise.
- x is called the independent or predictor variable
- y is called the dependent variable.

Clinical example with one output

$y_1 = \theta_0 + \theta_1 X_1$

Where

- y_1 is predicted nursing costs
- θ_o is intercept or base case when bed days = 0
- θ_1 is the amount that nursing costs changes with a unit increase in bed days
- x_1 is bed days

- Given a training set, how do we derive ϴ ?
- $ϴ_1$ is the amount that nursing costs changes with a unit increase in bed days
- One way to derive ϴ is to make h(x) as close as possible to y.
- So, we define $J(\theta)$

Cost function

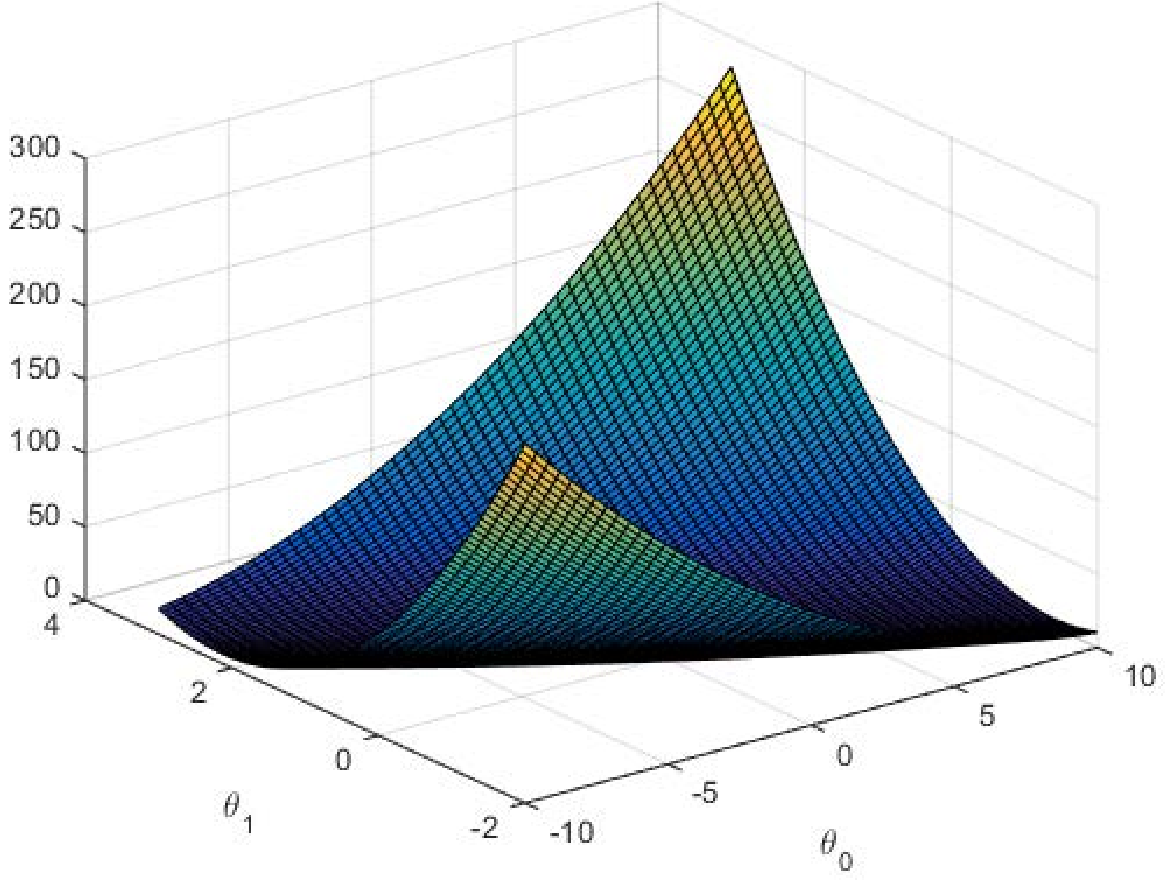
We define the cost function as

$J(\theta) = (1/2)\sum_{1}^{m}(h_0(x^i) - yi)^2$

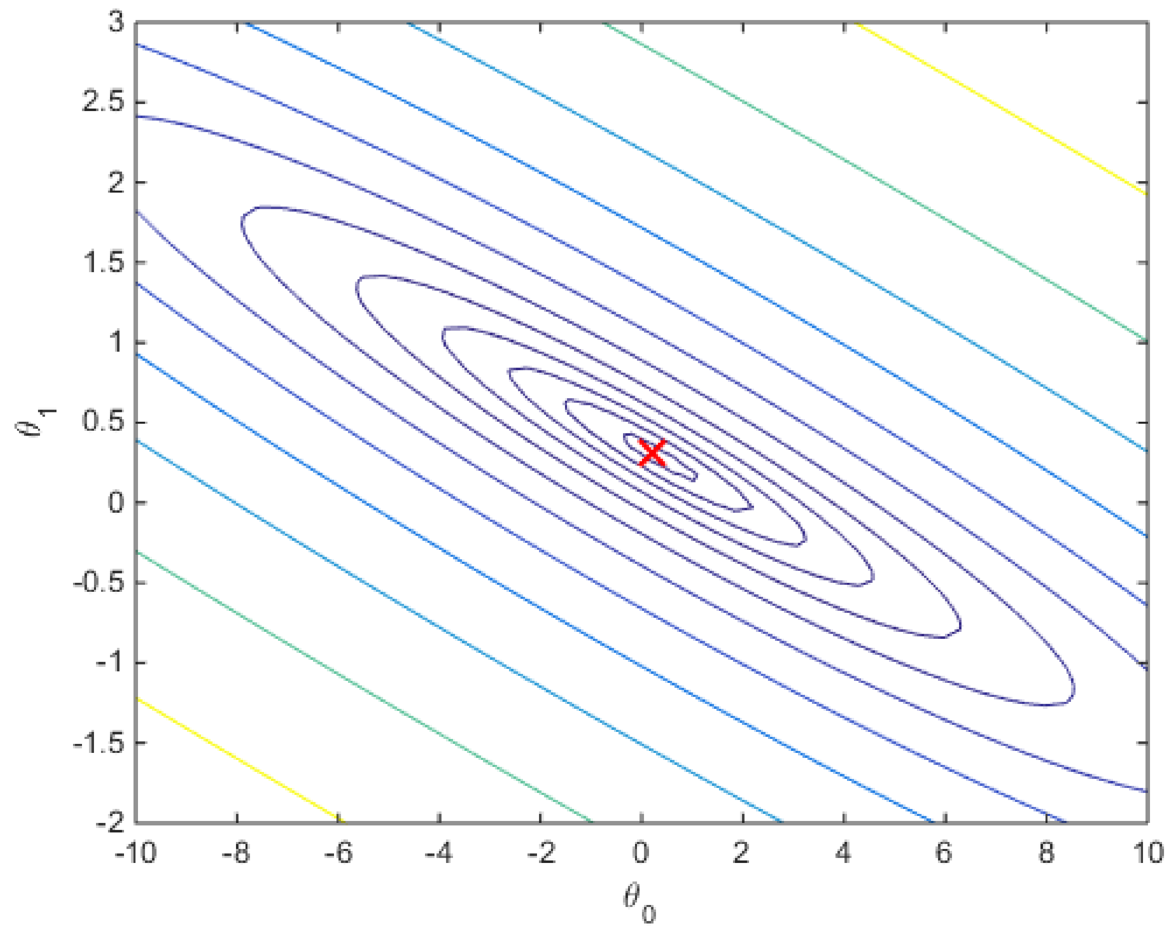
where this measures for each value of the Ɵ's (coefficients) how close the h(x)'s predict their corresponding y's.

Concretely, linear regression minimises $J(\theta)$!

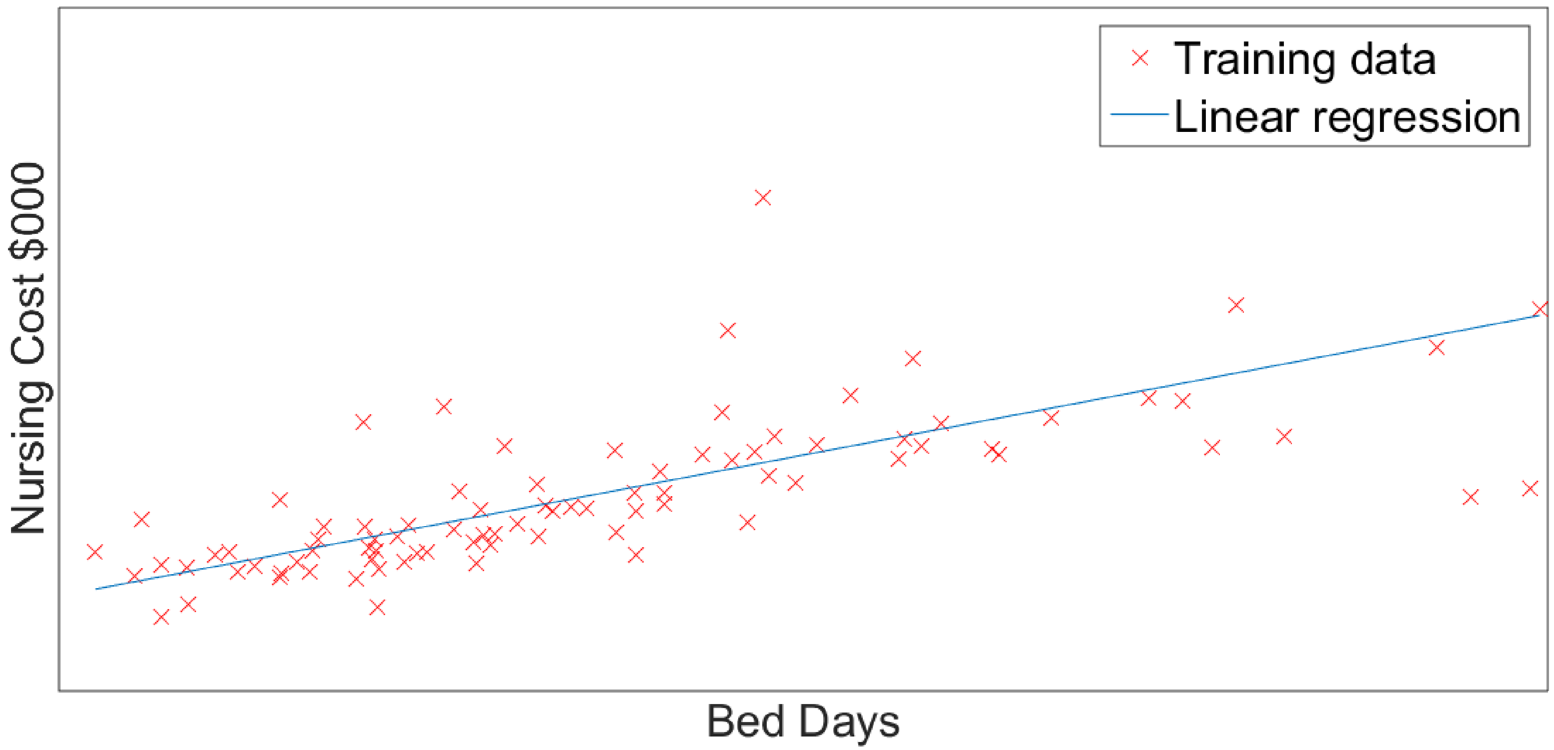
Surface plot of $J(\theta)$



Contour graph for $J(\theta)$



Data with linear regression fit



- So far, we have shown that key inputs, bed days, have a strong relationship to outputs i.e. nursing costs,
- Because the bowl shape has a global minimum.
- We will build upon this by using simple statistics to calculate multiple costs outputs.

Extending concept
to multiple outputs using one input

Multiple outputs from one input

- $y_1 + y_2 + y_3 .. + y_n = \Theta_0 + \Theta_n X_n$

Where

- y_1 is predicted AH costs, y_2 medical, y_3 nursing, etc
- Θ_0 is intercept or base case when bed days = 0
- Θ_n is the amount that costs change with a unit increase in bed days
- x_n is bed days

- If starting with raw data, we could use MANOVA or alternatively multivariate regression (not multiple regression).
- But…
- If you are in a public hospital, the data exists as part of your annual submission to your state and then to IHPA.

Using made up data for one episode

- $y_1 + y_2 + y_3 .. + y_n = \Theta_0 + \Theta_n X_n$

	Allied	Med	Nurse	Critical Care	Imag	Non Clinical	On Cost	Exclude	Other		Theta n	X n
$	373	920	1,544	899	189	642	458	200	2,557	=	1,688	5

- y_1 is predicted AH costs, y_2 medical, y_3 nursing, etc
- Θ_0 is intercept or base case when bed days = 0, Θ_n is the amount that costs change with a unit increase in bed days
- x_n is 5 bed days avg LOS

- Converting data on the righthand side using average daily dept costs, we get
- $0.25y_1 + 0.25y_2 + 0.84y_3 + \ldots = 1688 * 5$
  - Where the number before y_n is staffing FTE
- y_n is the average departmental cost
- 1688 is Θ_n and 5 is LOS.

Budgeting

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- For a hospital ward that is budgeted to deliver 25,000 bed days, budgeted staffing is:
- Allied (25,000 x .25) / 250 = 25 FTE
- Medical (25,000 x .25) / 250 = 25 FTE
- Nursing (25,000 x .84) / 250 = 84 FTE

- Convert the previous slide to dollars and you have the basis of a ward budget in both $ and headcount.
- The same methodology could be use for other depts.

Best practice

- If your service is > average cost, examine data to see where and why.
- Over time, improve costs towards the average, with a view to clinical best practice.

Summary

1. Costing data can be used to budget.
2. Develop budgets based on headcount and dollars.
3. Monitor performance against budget over the course of the year.