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How Powerful are your Rating Factors?

Chris Reynolds - PartnerRe

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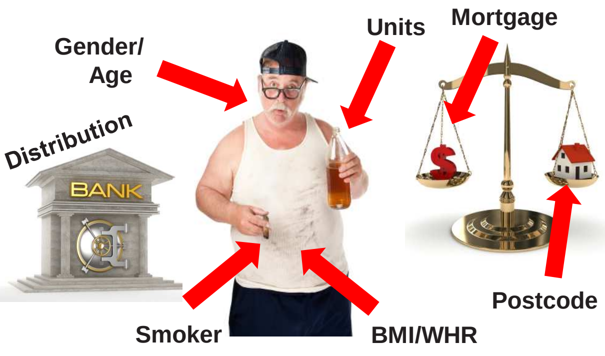
How do factors interact?



Source: istockphoto

Linear Regression

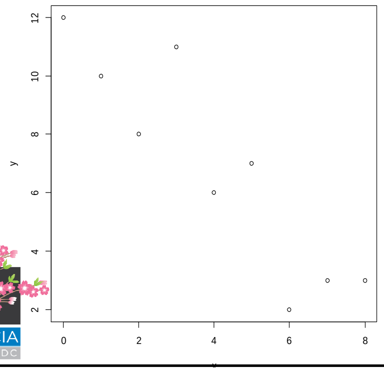
Random Structure
Responses vary even for constant values of the predictor

$$Y_i \sim N(\mu_i, \sigma^2)$$

Systematic Structure
The simplest way to express the dependence of the response μ_i on the predictor x_i is to assume a linear function

$$\mu_i = \alpha + \beta x_i$$

Linear Regression



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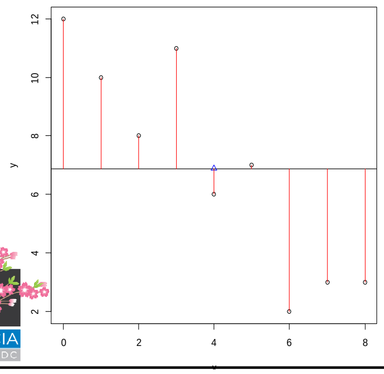
Linear Regression



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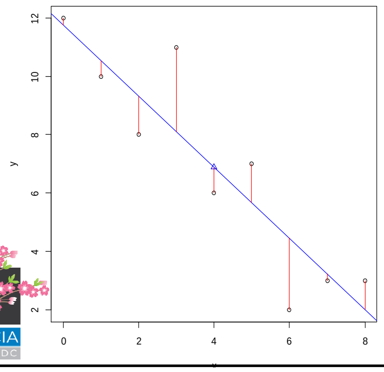
Linear Regression



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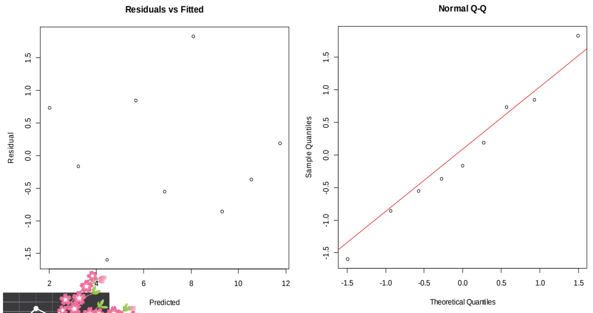
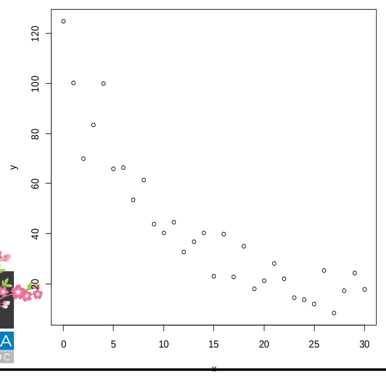
Linear Regression



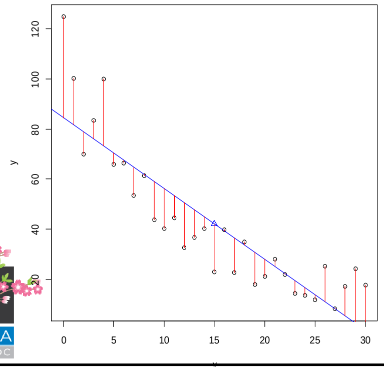
Source: PartnerRe

Linear Regression - Limitations



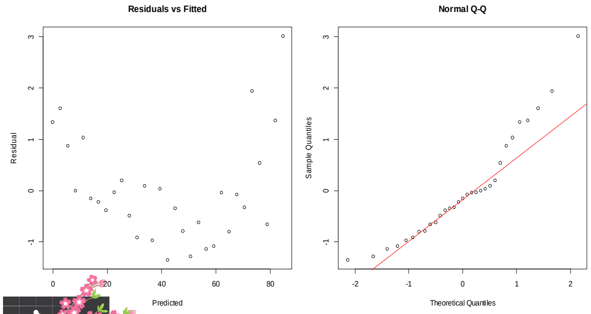
Source: PartnerRe

Linear Regression - Limitations



Source: PartnerRe

Linear Regression - Limitations



Source: PartnerRe

Linear Regression - Limitations

1 The relationship between the response and the predictor may not be linear;

2 A normal distribution for the response may be inappropriate;

3 The variance will often increase linearly with the mean, so a constant variance assumption may be inappropriate.

What do we do???

We <u>generalize</u> the model framework.

The 3 part GLM Recipe

1. **Random Component**
   Identify the response variable Y and assume a probability distribution for it

2. **Systematic Component**
   Specify what the explanatory variables X are. This gives the linear component $\alpha + \beta X_i$

3. **Link**
   Specify the relationship g between the mean E(Y) and the systematic component X:

$$g(\mathrm{E}[Y_i]) = \alpha + \beta X_i$$

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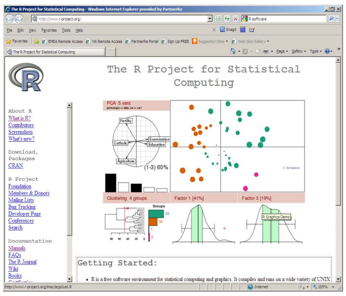
R Software – What is it?

"R is an open-source, object-oriented statistical programming language. In the past decade, it has become the global lingua franca of statistics"

www.r-project.org



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R – Should a company trust free software?

These companies do*

*Source : http://www.revolutionanalytics.com/what-is-open-source-r/companies-using-r.php

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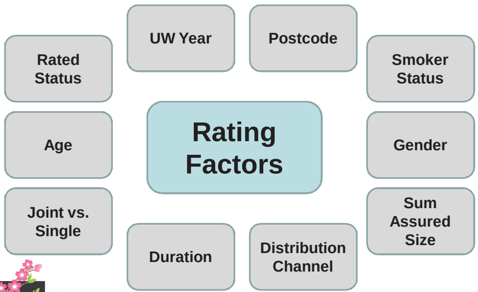
Real time demonstration

Using mortality data from the Human Mortality Database

www.mortality.org

Apply to your own datasets



Summary

- GLMs can be easily fitted with R, **but**

Source: Fotolia

Questions or comments?

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Appendix 1 - Poisson Regression

Number of Deaths: $Y_i \sim Po(n_i \mu_i) \;\Rightarrow\; E(Y_i) = n_i \mu_i$

Gompertz: $\mu_i = e^{x_i \beta}$

GLM: $\log[E(Y_i)] = \log n_i + x_i \beta$

This is called the "offset"

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Appendix 2 - Further Reading

- CMI – Working Paper 58 (2011)
- An Introduction to Generalized Linear Models, Dobson & Barnett (2008)
- Statistics : An Introduction using R, Crawley (2005)
- Generalized Linear Models for Insurance Data, Jong & Heller (2008)
- Demystifying GLMs (Sessional Meeting - Australia), Henwood et al (1991)
- Risk classification in life insurance: methodology and case study, Gschlössl, Schoenmaekers and Denuit (2011)
- Actuarial Graduation Practice and Generalised Linear and Non-Linear Models, Renshaw (1991)