Management Practice

5. People & Project management

6. Statistics in management

Jeroen.Bergmann@eng.ox.ac.uk

MPiE

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Course

Literature for the course:

Eisner, Howard. *Essentials of project and systems engineering management*. John Wiley & Sons, 2008.

Learning objective for this session:

- Able to mention key factors that influence management success
- Able to compute and critically a Pearson Correlation

Literature for this session:

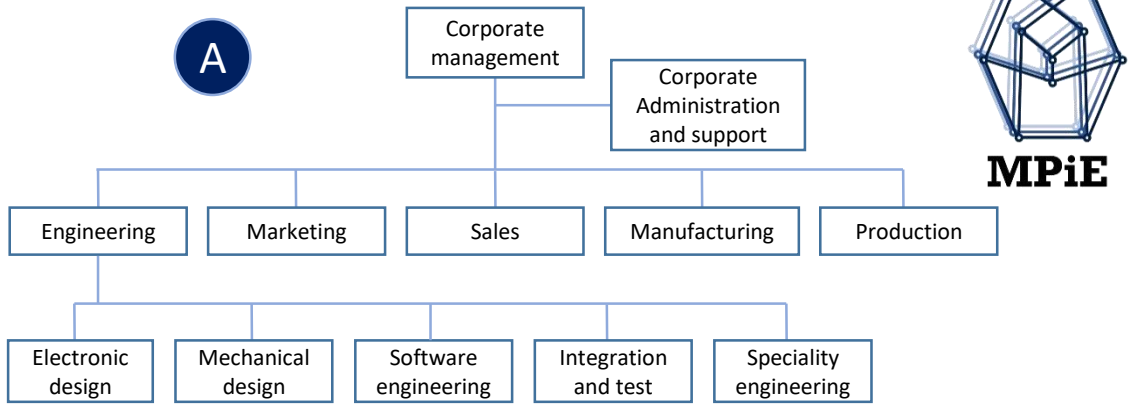
Zou, Kelly H., Kemal Tuncali, and Stuart G. Silverman. "Correlation and simple linear regression." *Radiology* 227.3 (2003): 617-628.

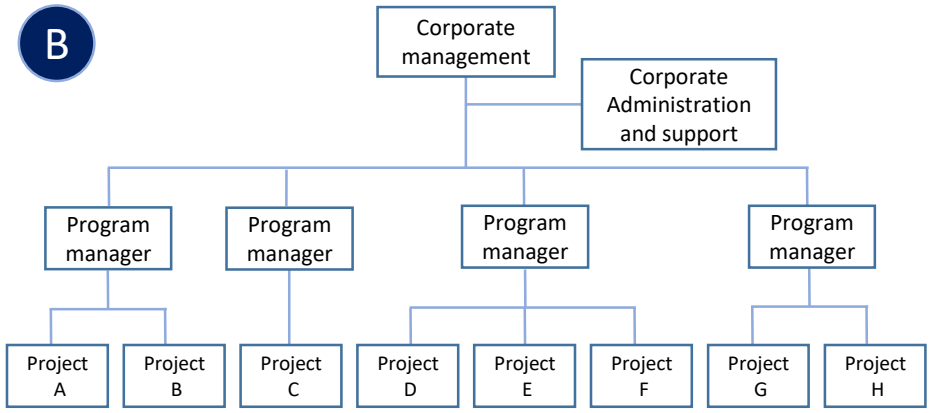
Hoaglin, David C., and Roy E. Welsch. "The hat matrix in regression and ANOVA." *The American Statistician* 32.1 (1978): 17-22.

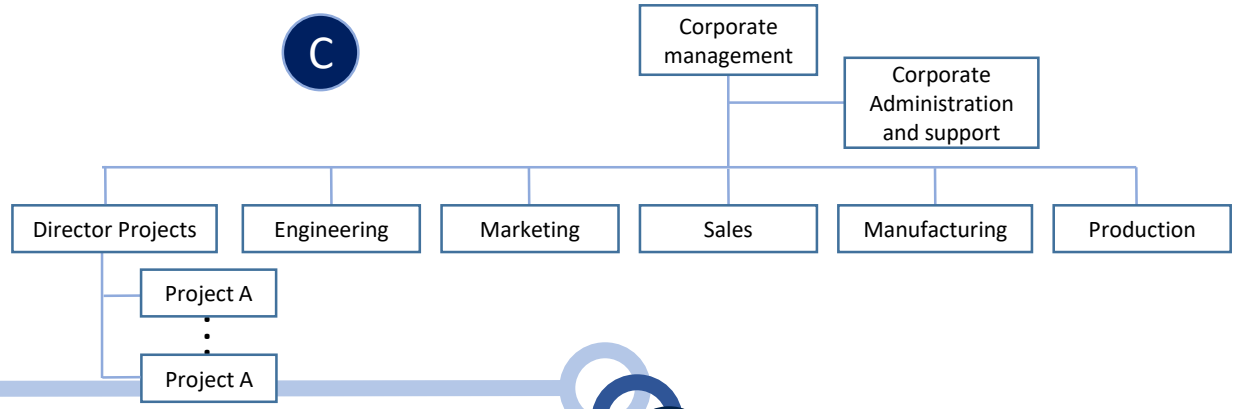
Cooke-Davies, Terry. "The ‘‘real’’success factors on projects." *International Journal of Project Management* 20 (2002): 185-190.

Cooperate organisations

- **Functional structure**, functional areas defined as e.g. engineering, marketing, sales, etc.
- **Project structure**, entire organization consists of a set of projects. Applicable in service industry reliant on external project calls.
- **Matrix structure**, a hybrid between functional and project structure. Internal competition between project and functional groups.
- People are managed within these structures.







Source: Eisner, Essentials of project and systems engineering management, 2008

Manager – simple view

Managing people is one of the most important leadership skills as it influences productivity through staff morale.

Take away message: There is a difference

Figure 1: Comparison of Management and Leadership Process Differences in the Workplace

Process	Management	Leadership
Vision Establishment	• Plans and budgets • Develops process steps and sets timelines • Displays impersonal attitude about the vision and goals	• Sets the direction and develops the vision • Develops strategic plans to achieve the vision • Displays very passionate attitude about the vision and goals
Human Development and Networking	• Organizes and staffs • Maintains structure • Delegates responsibility • Delegates authority • Implements the vision • Establishes policy and procedures to implement vision • Displays low emotion • Limits employee choices	• Aligns organization • Communicates the vision, mission, and direction • Influences creation of coalitions, teams, and partnerships that understand and accept the vision • Displays driven, high emotion • Increases choices
Vision Execution	• Controls processes • Identifies problems • Solves problems • Monitors results • Takes low-risk approach to problem solving	• Motivates and inspires • Energizes employees to overcome barriers to change • Satisfies basic human needs • Takes high-risk approach to problem solving
Vision Outcome	• Manages vision order and predictability • Provides expected results consistently to leadership and other stakeholders	• Promotes useful and dramatic changes, such as new products or approaches to improving labor relations

Source: Kotterman (2006) *The Journal for Quality and Participation* 29.2

Project

- “A project is **temporary** in that it has a defined beginning and end in time, and therefore defined scope and resources.”
- “[A] project is **unique** in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. So a project team [could] include people who don’t usually work together – sometimes from different organizations and across multiple geographies.”
- **Project management**, then, is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.

Source: PMI

Project management

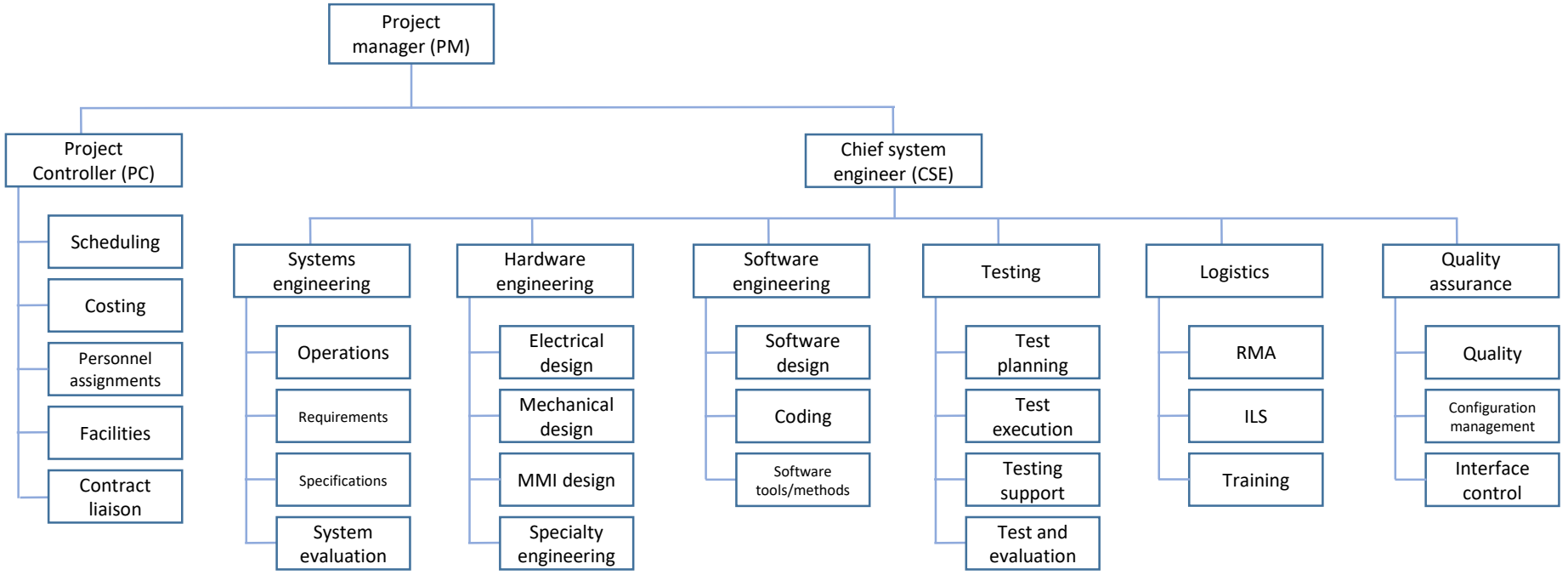
Project problems often occur in terms of:

1. Schedule (time)
2. Cost (as compared with the original budget)
3. Performance and quality

Project management thus means you make sure you are on time, budget and in scope as well as on spec.

Source: Eisner, Essentials of project and systems engineering management, 2008

Project management



RMA = reliability-maintainability-availability
ILS = integrated logistics support
MMI = man-machine interface

Source: Eisner, Essentials of project and systems engineering management, 2008

Project management success

- Project success = measured against the overall objectives of the project

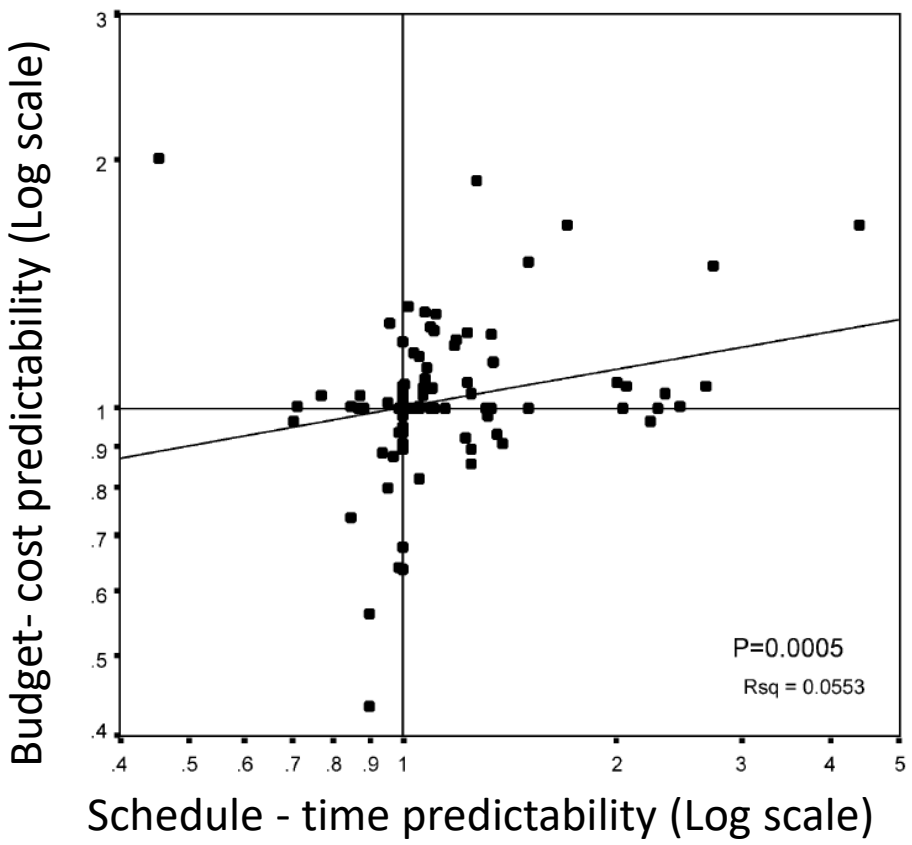
- Project success cannot be measured until after the project is completed, whilst project performance can be measured during the life of the project

- Project management success = measured against the widespread and traditional measures of performance against cost, time and quality

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Project management success

- Each point on the graph represents one of the projects and its performance against schedule (on the x axis) and budget (on the y axis).
- Mean performance against budget (cost escalation) is generally better than mean performance against schedule (lateness)



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

r – Pearson correlation coefficient

- Pearson correlation coefficient is applicable to interval or continuous (scale/interval) data.

- Pearson correlation is a parametric test (it makes assumptions about the parameters of the underlying population distribution).

- The Spearman correlation coefficient can be based on continuous data and it measures the monotonic relationship between two variables (scale/interval or ordinal data).

Source: Zou, Kelly et al , 2003

Spearman’s rank correlation coefficient

The Spearman's rank correlation coefficient can be seen in a simple way as a non-parametric version of the Pearson product-moment correlation

$$r_{spear} = 1 - \frac{6\left(\sum_{i=1}^{n} d_i^2\right)}{n(n^2 - 1)}$$

d is the difference between two ranks and *n* is number of pairs of data

low to high	
x rank	y rank
1	1
2	4.5
3	6
4	2
5	4.5
6	3

Note: When 2 values (or more) are tied with the same rank, you must give them the same rank number which must be the average between the tied ranks

Note: Kendall’s other rank correlation

r – Pearson correlation coefficient

Population

$$\rho_{X,Y} = \frac{Cov(X,Y)}{\sigma_x \sigma_Y}$$

$$Cov(X,Y) = E[(X - \mu_x)(Y - \mu_Y)]$$

$$Cov(X,Y) = covariance$$

$$\mu = mean$$

$$\sigma = standard\ deviation$$

$$\rho = population\ correlation$$

Sample

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\,(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

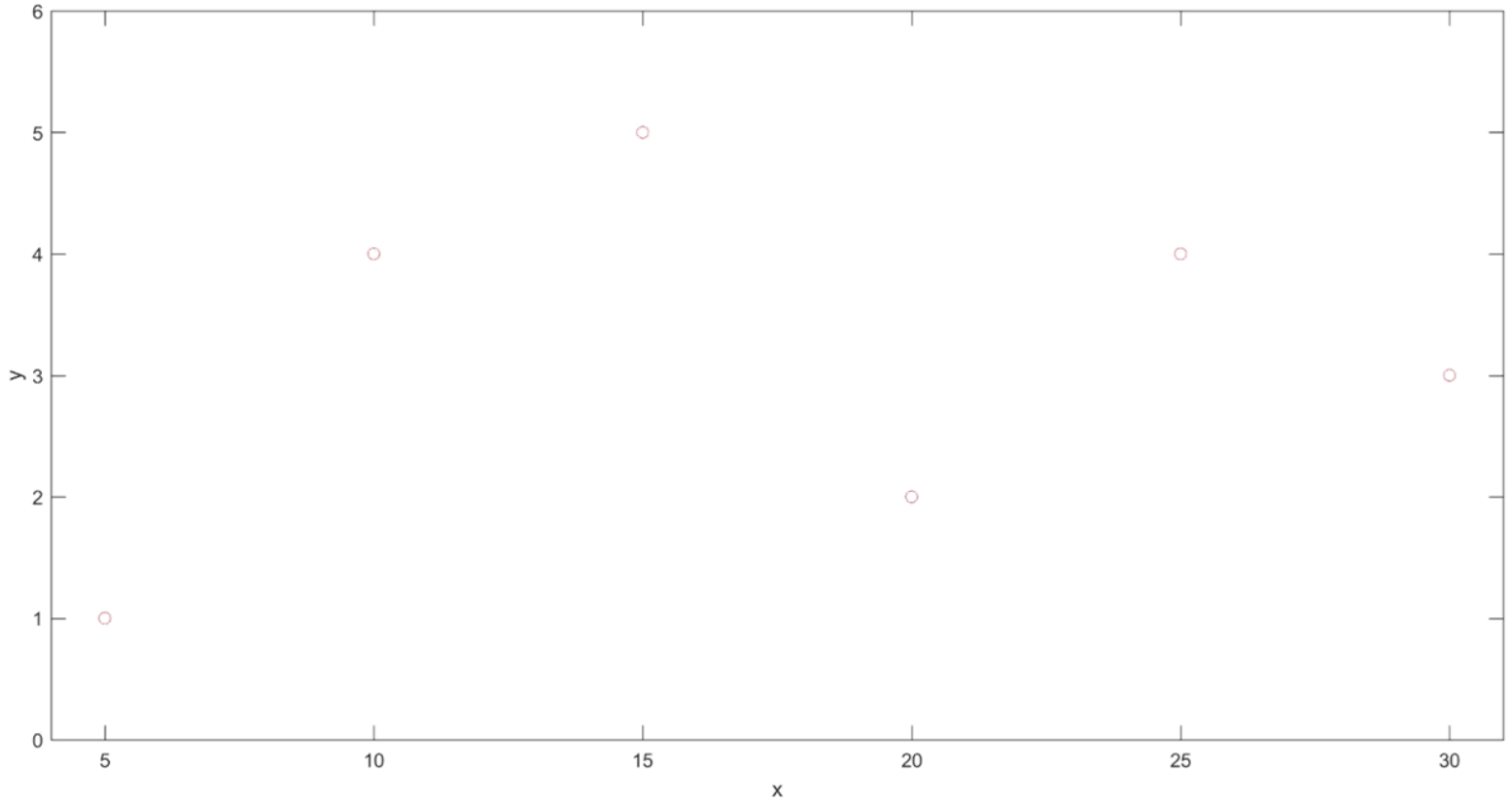
$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \ \ same\ for\ \bar{y}$$

Properties of *r*

- *r* is a number between -1 and 1
- *r(X,Y)=r(Y,X)*
- *r = 1* or *r = -1* indicates a perfect correlation
- *r > 0* indicates positive association
- *r < 0* indicates negative association

Calculating *r*

x (A.U.)	y (A.U.)
5	1
10	4
15	5
20	2
25	4
30	3



$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} = .2542$$

Ratio of the **co-variability** (numerator) of x and y to the **variability** (denominator) of x and y independently

Anscombe's Quartet

Correlation

$r = .67$

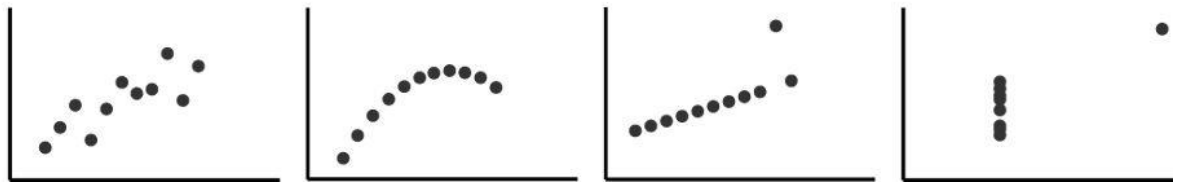
Linear regression

$y = 3 + .5x$

a

I		II		III		IV	
x	*y*	*x*	*y*	*x*	*y*	*x*	*y*
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.10	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.10	4	5.39	19	12.5
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

b



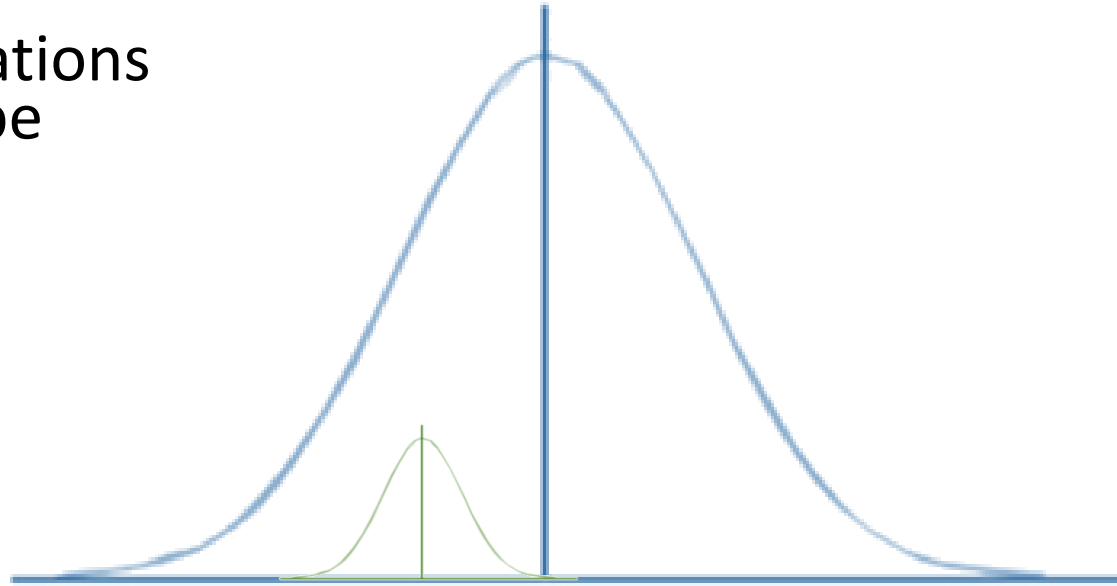
Source: Shoresh & Wong, Nature methods, 2012

Statistical hypothesis testing *r*

- The value *r* indicates the strength of a linear relationship in **samples** only. Thus, for a different sample a different value can be obtained.

- The aim is to draw conclusions over populations not samples, so a confidence interval can be calculated or a hypothesis test can be conducted.

- A hypothesis test can be conducted for the population correlation coefficient ρ.



Statistical hypothesis testing for *r*

- The null hypothesis (H_0) states that there is no correlation between *x* and *y* variables in the population.
- The alternative hypothesis (H_1) states that there is a correlation between *x* and *y* variables in the population.

$$H_0: \rho = 0$$

$$H_1: \rho \neq 0$$

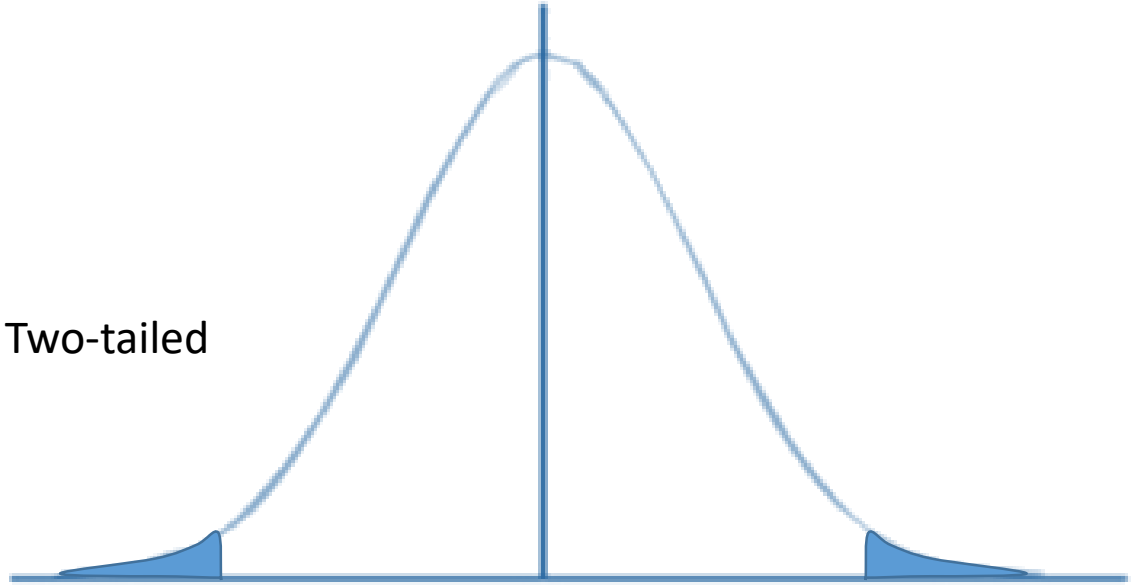
- A *t*-test (*df: n-2* ∵ *pairs*) for the correlation coefficient can be performed to test the hypothesis.
- Increasing *t*-values (with fixed *df*) indicates higher probability of H_1 being correct.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Calculating t

x (A.U.)	y (A.U.)
5	1
10	4
15	5
20	2
25	4
30	3

Two-tailed



$$t = r\sqrt{\frac{n-2}{1-r^2}} = 0.5257$$

$$p = .6269 > \alpha = .05$$

$$Upper\ 95\%\ CI = .6269$$

$$Lower\ 95\%\ CI = -.7022$$

Different ways of calculating the subsequent p-value using e.g. Simpson's Rule,
Monte Carlo Integration or NBS Approximation.

The formula or a look-up table can be used from HLT

Linear regression

Objective is to minimise the distances between data points and model (line)

$$y = mx + b$$

Set up a loss function *L*, with $\hat{y}$ being the estimated value of our model

$$L(\hat{y}, y) = \frac{1}{2}(\hat{y} - y)^2$$

Sum of squared distances is Sum of Squares (*S*) - [no need for $\frac{1}{2}$]

$$S = \sum_{i=1}^{n}\left((mx_i + b) - y_i\right)^2 = \sum_{i=1}^{n}(\hat{y}_i - y_i)^2 = \sum_{i=1}^{n} d_i^2$$

$$\therefore S = \sum_{i=1}^{n}(mx_i + b)^2 - 2(mx_i + b)y_i + y_i^2 = \sum_{i=1}^{n}\left(m^2x_i^2 + 2bmx_i + b^2\right) - 2mx_iy_i - 2by_i + y_i^2$$

Minimise sum based on parameter *m* and *b* by applying partial derivatives

Linear regression

For

$$S = \sum_{i=1}^{n} \left(m^2 x_i^2 + 2bmx_i + b^2\right) - 2mx_i y_i - 2by_i + y_i^2$$

$$\frac{\partial S}{\partial b} = \sum_{i=1}^{n} (2mx_i + 2b - 2y_i)$$

Set

$$\frac{\partial S}{\partial b} = 0$$

Divide both sides by 2

$$m\left(\sum_{i=1}^{n} x_i\right) + \left(\sum_{i=1}^{n} b\right) - \left(\sum_{i=1}^{n} y_i\right) = 0 \qquad \rightarrow nm\bar{x} + nb - n\bar{y} = 0 \rightarrow \boxed{\bar{y}=m\bar{x} + b}$$

Linear regression

For

$$S = \sum_{i=1}^{n} \left(m^2 x_i^2 + 2bmx_i + b^2\right) - 2mx_i y_i - 2by_i + y_i^2$$

$$\frac{\partial S}{\partial m} = \sum_{i=1}^{n} \left(2mx_i^2 + 2bx_i - 2x_i y_i\right)$$

Set

$$\frac{\partial S}{\partial m} = 0$$

Divide both sides by 2

$$\mathrm{m}\left(\sum_{i=1}^{n} x_i^2\right) + b\left(\sum_{i=1}^{n} x_i\right) - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \qquad \rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + bn\bar{x} - n\left(\sum_{i=1}^{n} x_i y_i\right) = 0$$

Linear regression

From the previous slide $\frac{\partial S}{\partial b}$

$$\bar{y} = m\bar{x} + b \rightarrow b = \bar{y} - m\bar{x}$$

$$m\left(\sum_{i=1}^{n} x_i^2\right) + bn\bar{x} - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + (\bar{y} - m\bar{x})n\bar{x} - \left(\sum_{i=1}^{n} x_i y_i\right) = 0$$

$$\rightarrow m\left(\sum_{i=1}^{n} x_i^2\right) + n\bar{x}\bar{y} - mn\bar{x}^2 - \left(\sum_{i=1}^{n} x_i y_i\right) = 0 \rightarrow m\left[\left(\sum_{i=1}^{n} x_i^2\right) - n\bar{x}^2\right] = \left(\sum_{i=1}^{n} x_i y_i\right) - n\bar{x}\bar{y}$$

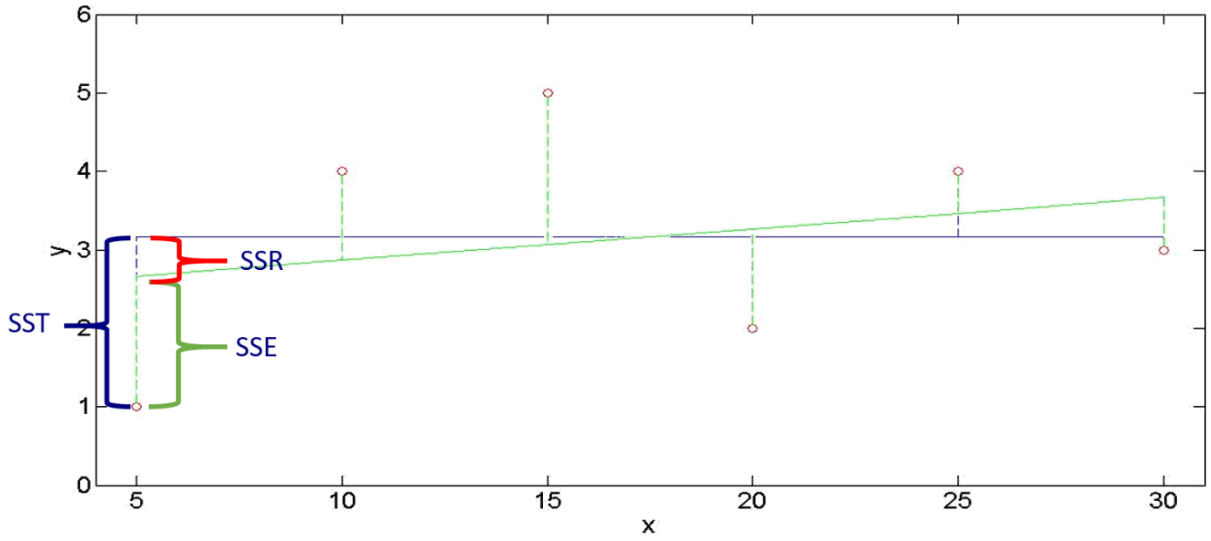
$$m = \frac{\left(\sum_{i=1}^{n} x_i y_i\right) - n\bar{x}\bar{y}}{\left(\sum_{i=1}^{n} x_i^2\right) - n\bar{x}^2} = \frac{s_{xy}}{s_{xx}} \qquad \frac{"Covaraiance\ x, y"}{"Variance\ x"}$$

R^2 – coefficient of determination

- R^2 is a measure that provides information about the goodness of fit for a (linear) model.

$$R^2 = \frac{sum\ squared\ regression\ (SSR)}{total\ sum\ of\ squares\ (SST)} = 1 - \frac{sum\ squared\ errors\ (SSE)}{total\ sum\ of\ squares\ (SST)} = 1 - \frac{\sum(y_i - \hat{y})^2}{\sum(y_i - \bar{y})^2}$$

$$SST = SSR + SSE$$



R^2 – coefficient of determination

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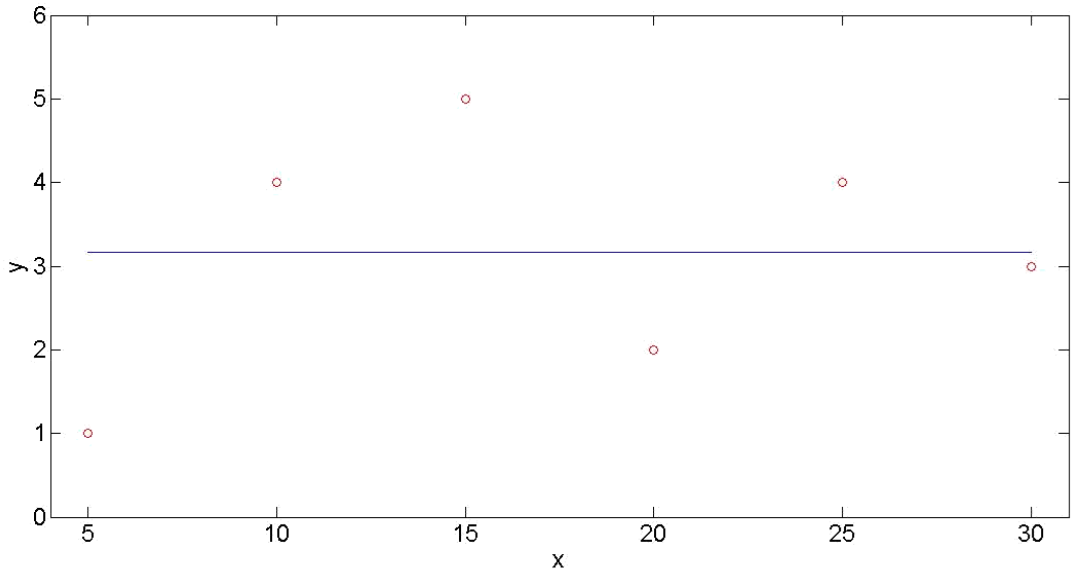

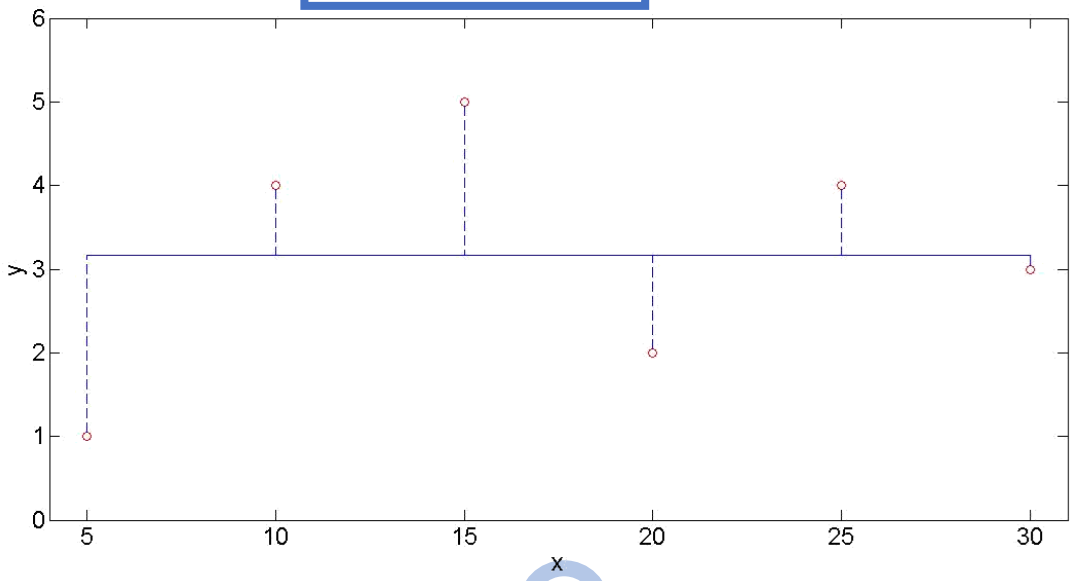

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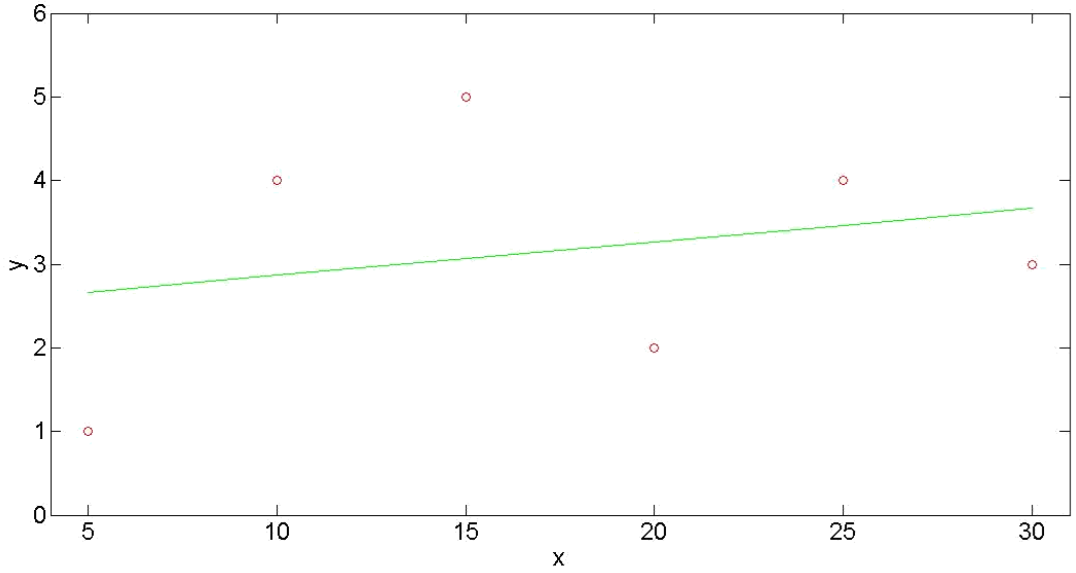
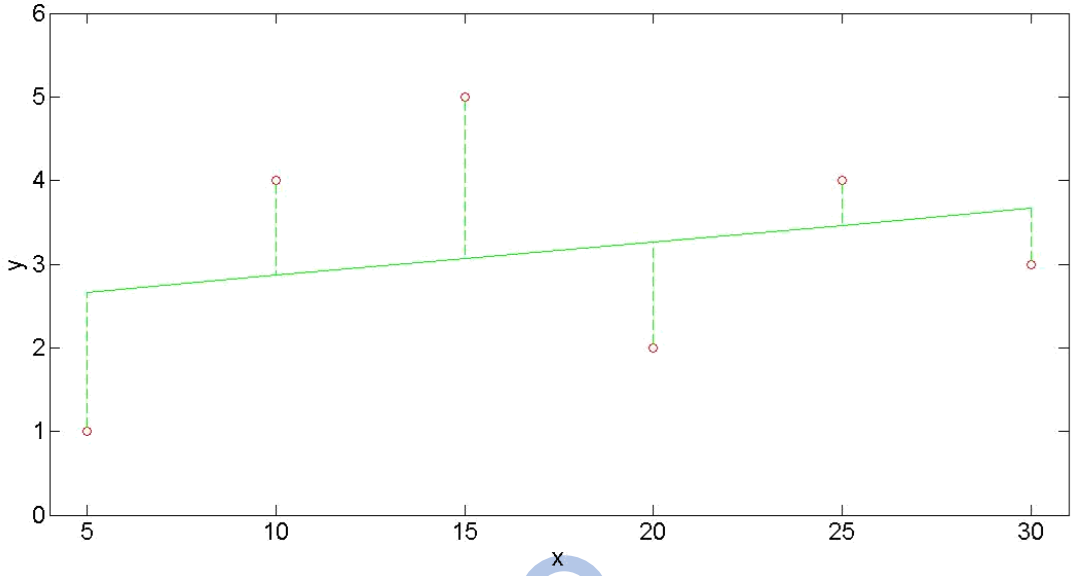




R^2 – coefficient of determination

- R^2 compares the errors of your regression model to the errors of a model based on the mean of *y*.

- It provides a fraction of unexplained variance since it compares the unexplained variance (variance of the model's errors) with the total variance (of the data).

- There is an assumption of linearity

Multiple regression model for prediction

A multiple linear regression model with *k* predictor variables v_1, v_2, ..., v_k
and a response y , can be written as

$$y = \beta_0 + \beta_1 v_1 + \cdots \beta_k v_k + \epsilon$$

with ϵ being the residual term(s) of the model and$\beta_0 \ \cdots \beta_k$ are the regression coefficients (higher powers can be included in more complex models)

The model can also include interaction effects of two or more variables

$$y = \beta_0 + \beta_1 v_1 + \beta_{12} v_1 v_2 \cdots \beta_k v_k + \epsilon$$

Any model with a linear combinations of β parameters can be seen as a linear model.

R^2 – multiple regression

- Overfitting can occur if the too many independent variables (predictors) are included, as it begins to model random noise in the data. It can lead to the creation of higher order polynomials.

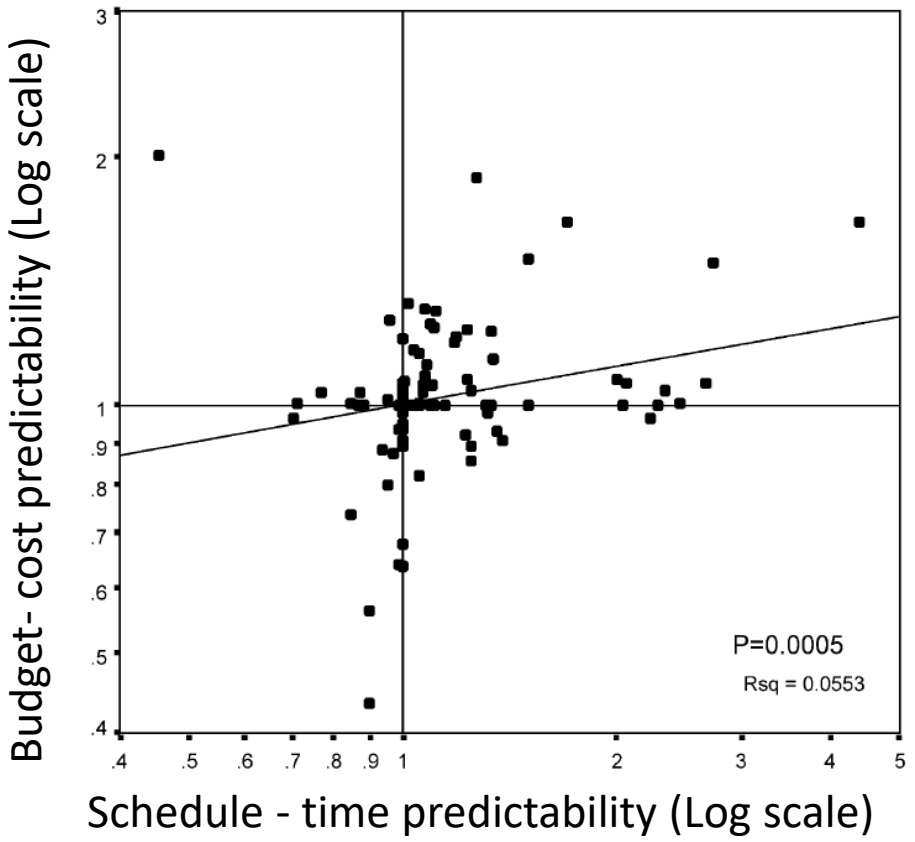
- The adjusted R^2 has been adjusted for the number of predictors in the model.

$$R^2_{adj} = 1 - \frac{SSR/n-(k+1)}{SST/n-1}$$

n= sample size; *k*=number of independent variables

Project management success

- There is a low R^2 value indicating that ~6% of the of the variance in the budget variable is predictable from the schedule variable.
- Budget and time predictability have a weak connection.



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect on-cost performance

- Allowing changes “to scope” only through a mature scope change control process.

- Maintain the integrity of the performance measurement baseline.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

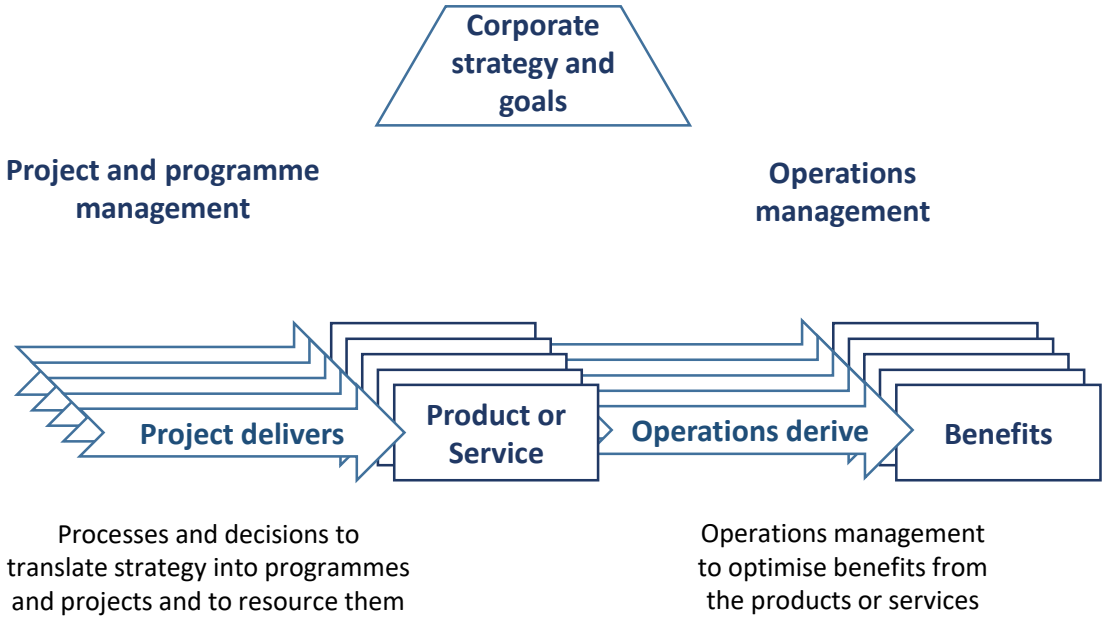
Factors that effect on-time performance

- Adequacy of company-wide education on the concepts of risk management.
- Maturity of an organisation's processes for assigning ownership of risks.
- Adequacy with which a visible risk register is maintained.
- Adequacy of an up-to-date risk management plan.
- Adequacy of documentation of organisational responsibilities on the project.
- Keep project (or project stage duration) as far below 3 years as possible (1 year is better).

Source: Cooke-Davies, The ''real'' success factors on projects, 2002

Factors to success on individual projects

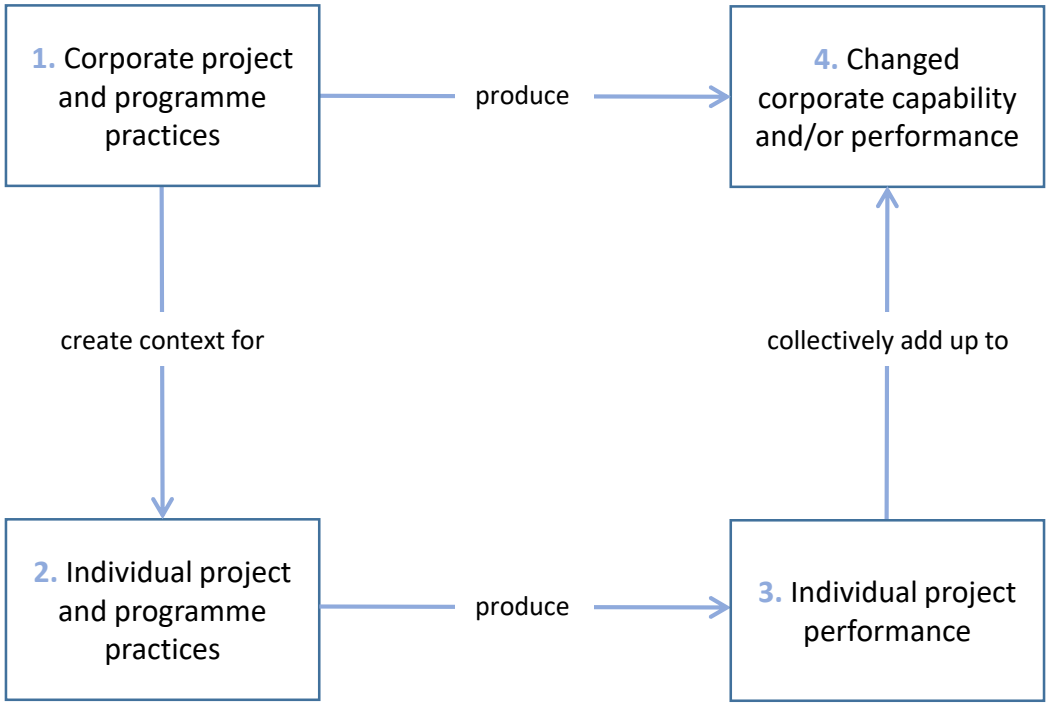
- Project success ≠ project management success.
- It requires the existence of an effective benefits delivery and management process that involves the mutual co-operation of project management and line management functions.
- The benefits are what the stakeholder hoped to achieve through the project



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect corporate project success

Schematic context representation



Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

Factors that effect corporate project success

- Portfolio- and programme management practices that allow the enterprise to resource fully a suite of projects that are thoughtfully and dynamically **matched to the corporate strategy and business objectives**.

- A suite of project, programme and portfolio **metrics** that provides direct ‘‘line of sight’’ feedback on current project performance, and anticipated future success, so that project, portfolio and corporate decisions can be aligned.

- An effective means of ‘‘learning from experience’’ on projects, that combines explicit knowledge with **encouraging people to learn** and to embed that learning into **continuous improvement** of project management processes and practices.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

The human skills imperative

- People perform every process that is prescribed and it is people who ultimately determine the adequacy of the factors described.

- The ‘‘people’’ side of the success factors is therefore essential.

Source: Cooke-Davies, The ‘‘real’’ success factors on projects, 2002

People perspective

The New York Times — March 13, 2011

Google's Rules

To engineer better managers, Google pored over performance reviews, feedback surveys and award nominations, correlating words and phrases as only a data-driven company like it can do. Here is an edited list of the directives it produced — in order of importance — as well as a few management pitfalls it found.

Eight Good Behaviors

1. Be a good coach
- Provide specific, constructive feedback, balancing the negative and the positive.
- Have regular one-on-ones, presenting solutions to problems tailored to your employees' specific strengths.

2. Empower your team and don't micromanage
- Balance giving freedom to your employees, while still being available for advice. Make "stretch" assignments to help the team tackle big problems.

3. Express interest in team members' success and personal well-being
- Get to know your employees as people, with lives outside of work.
- Make new members of your team feel welcome and help ease their transition.

4. Don't be a sissy: Be productive and results-oriented
- Focus on what employees want the team to achieve and how they can help achieve it.
- Help the team prioritize work and use seniority to remove roadblocks.

5. Be a good communicator and listen to your team
- Communication is two-way: you both listen and share information.
- Hold all-hands meetings and be straightforward about the messages and goals of the team. Help the team connect the dots.
- Encourage open dialogue and listen to the issues and concerns of your employees.

6. Help your employees with career development

7. Have a clear vision and strategy for the team
- Even in the midst of turmoil, keep the team focused on goals and strategy.
- Involve the team in setting and evolving the team's vision and making progress toward it.

8. Have key technical skills so you can help advise the team
- Roll up your sleeves and conduct work side by side with the team, when needed.
- Understand the specific challenges of the work.

Three Pitfalls of Managers

1. Have trouble making a transition to the team
- Sometimes, fantastic individual contributors are promoted to managers without the necessary skills to lead people.
- People hired from outside the organization don't always understand the unique aspects of managing at Google.

2. Lack a consistent approach to performance management and career development
- Don't help employees understand how these work at Google and doesn't coach them on their options to develop and stretch.
- Not proactive, waits for the employee to come to them.

3. Spend too little time managing and communicating

Source: Google

People practice

- Research found an almost even split in top-rated internal best practices between technical and people practices.

- The people skills set that successful teams have included the formation of high-calibre project teams, stakeholder participation, effective team and external communication, customer satisfaction, conflict management, and staff management and motivation

Source: Loo, Working towards best practices in project management: a Canadian study, 2002; Loo, multi-level causal model for best practices in project management benchmarking, 2003

People practice

- The fact that humans, under the appropriate conditions, can expand their contributions tremendously is what distinguishes them from other resources.

- Management may create a climate for motivation by enriching jobs in the following way:

1. Removing some controls while retaining accountability
2. Increasing the accountability of individuals for their own work
3. Giving a person a complete, natural unit of work (module, division, area, etc.)
4. Granting additional authority to an employee in his activity; job freedom
5. Making periodic reports directly available to the worker himself rather than to his supervisor
6. Introducing new and more difficult tasks not previously handled
7. Assigning individuals specific or specialized tasks, enabling them to become experts.

Source: Murdick, Managing human resources in project management, 1976

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Questions?

jeroen.bergmann@eng.ox.ac.uk