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Productivity of Software Enhancement Projects: an Empirical Study

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Abstract

- Background. In some environments, it is believed that software enhancement projects have higher productivity than new software development.
- Aim. Understand if this belief is rooted on solid bases or is due to some cognitive biases.
- Method. An empirical study was performed, using several statistical methods.
- Results. Software enhancement appears to cost more than new software development, at least for projects greater than 300 Function Points.
- Conclusions. We should reject ill-based evaluations that the productivity of software enhancement is greater than new software development.

Motivations

- We have observed the tendency to consider the enhancement of existing software as less demanding than the development of new software.
- I.e., it is believed that enhancing software costs less than developing new software
  - In terms of unitary effort, i.e., person hours per FP
- Such beliefs can have quite relevant consequences: e.g., setting unrealistic prices for software enhancement contracts.
- Therefore, it is of great importance to understand if the belief is rooted on solid bases, or it is affected by cognitive biases.
- This is the objective of our empirical study

The dataset

- We analyzed data from the ISBSG dataset
- Selection criteria:
  - size measured in IFPUG Function Points
  - Data Quality Rating equal to B or better
  - UFP rating equal to B or better
  - Projects too big or too small were also removed.
    - Projects having size smaller than 50 UFP are too noisy
    - Projects having size greater than 800 UFP we excluded because there were too few to support analogy-based estimation.

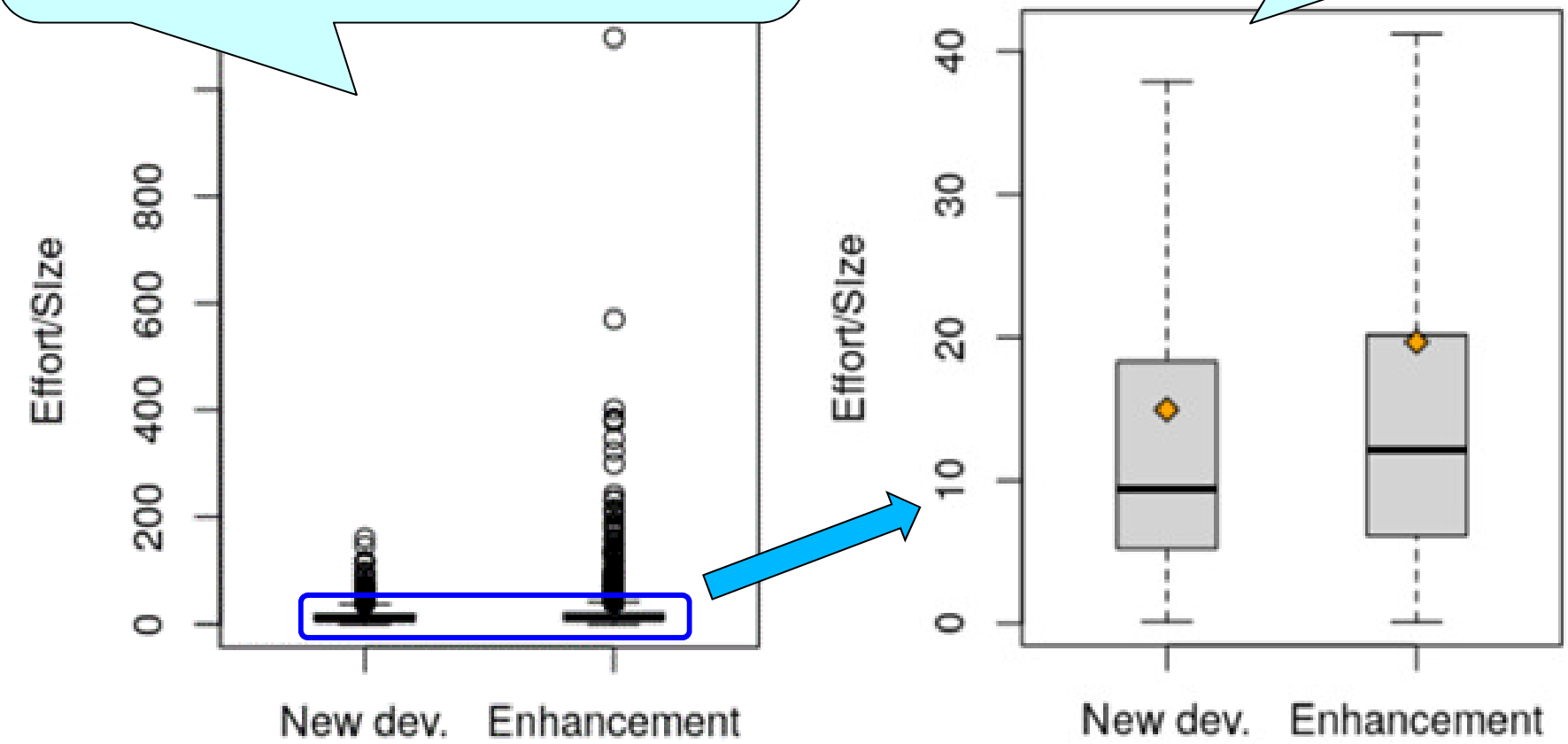
The dataset: descriptive statistics

	New Development		Enhancement
Num. projects	861		2935
Size range	[50, 800]		[50, 800]
Size mean	292	166%	176
Size st. dev.	186		149
Size median	246		119
Effort range	[64, 45778]		[31, 92380]
Effort mean	3852	127%	3032
Effort st. dev.	4655		5029
Effort median	2385		1532

Unitary effort boxplots

Unitary effort required by enhancement projects is generally greater
Several enhancement projects required a very large amount of effort per FP

Both the mean and the median are greater for enhancement projects



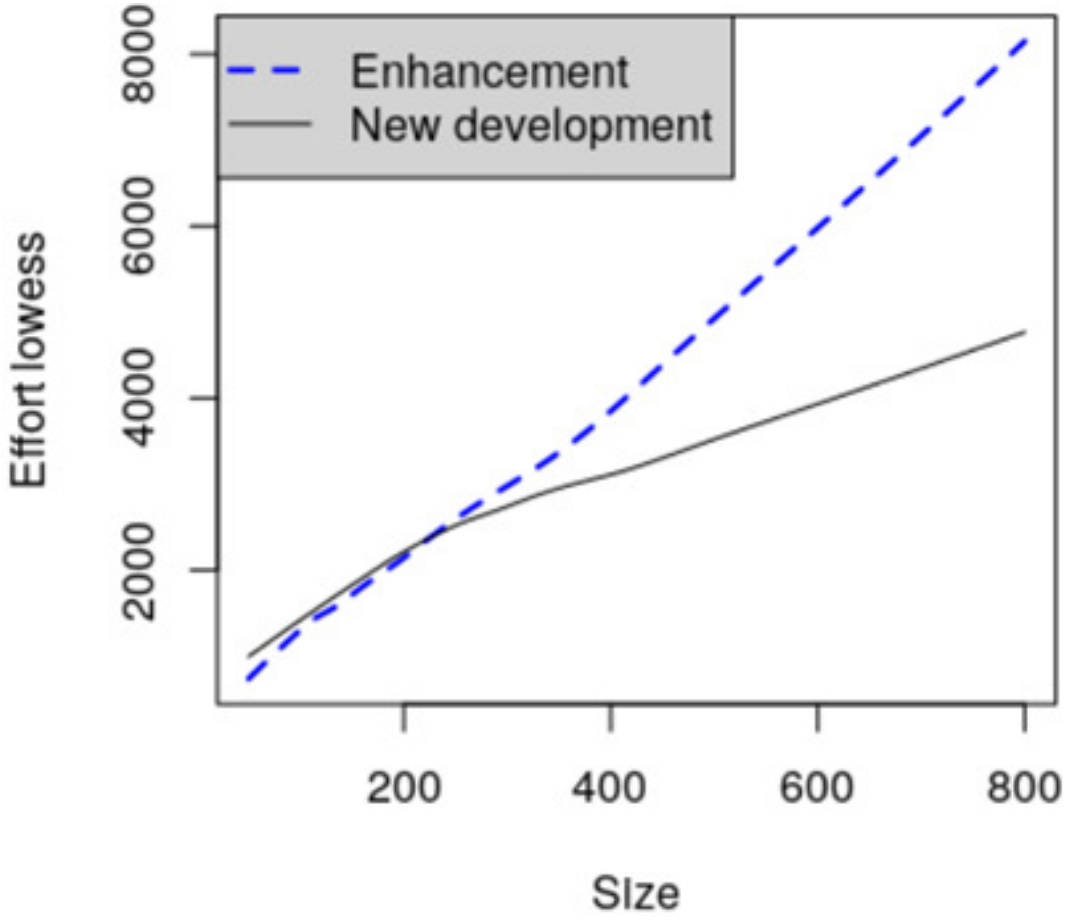
Unitary effort statistics

	New Development	Enhancement
Median	9.41	12.12
Range	[0.13, 160.9]	[0.11, 1097.4]
Mean	14.95	19.67
St. dev.	16.75	36.65

It appears that Enhancement projects require more effort per FP than new development projects.

This fact was tested by means of the Wilcoxon rank sum test, which confirmed that the probability that a randomly selected New development effort per FP is less than a randomly selected Enhancement effort per FP is significantly greater than the probability of picking a greater or equal effort per FP value.

lowess curves



- Lowess (locally weighted scatterplot smoothing) is a nonparametric method for fitting a smooth curve between two variables

Linear regression models

OLS linear models for New development and Enhancement projects

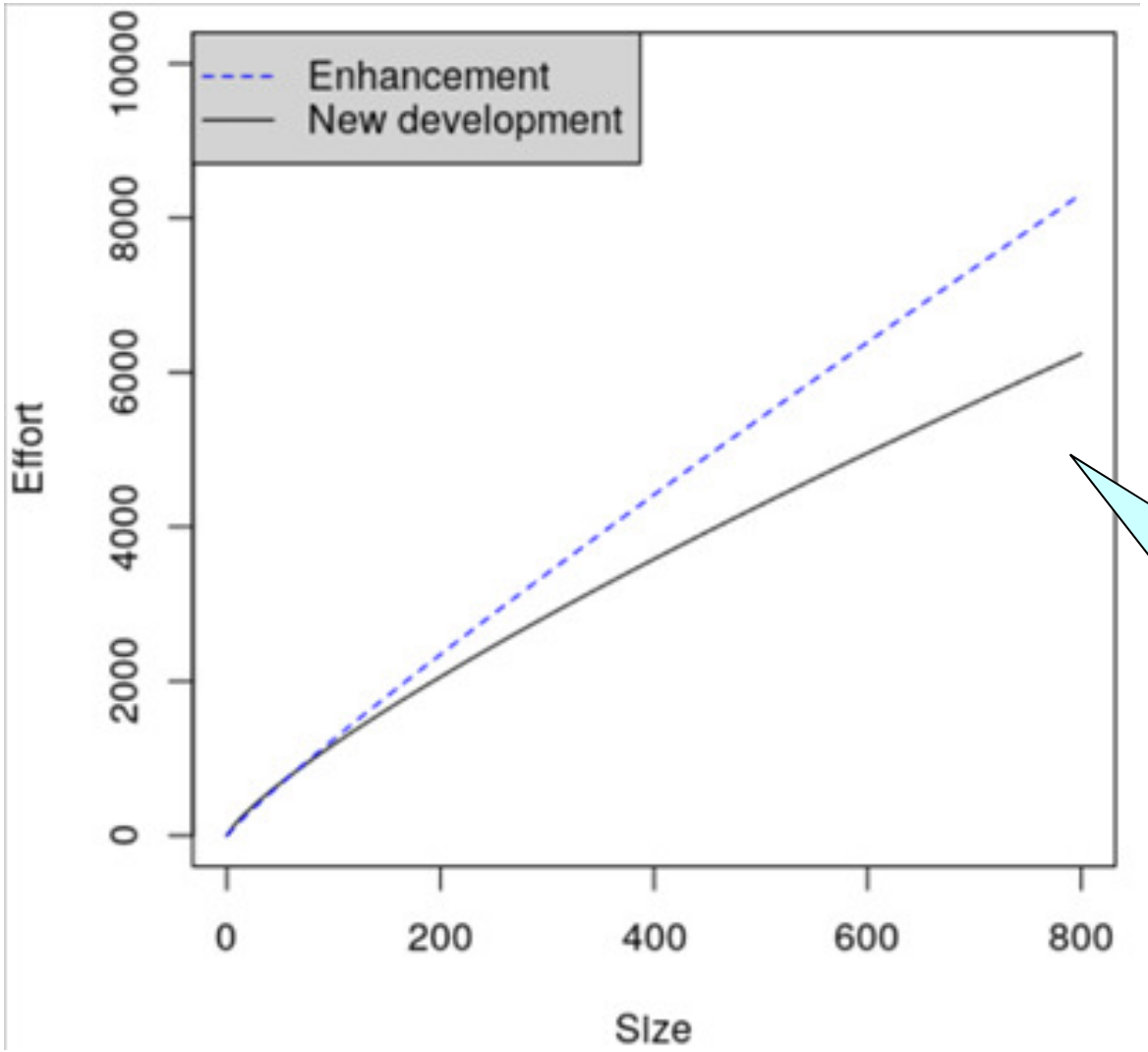
	New Development	Enhancement
Model	Effort = 9 Size	Effort = 11.48 Size
Num. outliers	292 (34%)	1172 (40%)
P value	$< 2^{-16}$	$< 2^{-16}$
Adjusted R^2	0.76	0.82
Normal residuals	**NO**	**NO**

Non-linear regression models

OLS log-log models for New development and Enhancement projects

	New Development	Enhancement
Model	Effort = 29.5 $Size^{0.801}$	Effort = 18.7 $Size^{0.912}$
Num. outliers	100 (12%)	454 (15%)
P value	$< 2^{-16}$	$< 2^{-16}$
Adjusted R^2	**0.31**	**0.42**
Normal residuals	Yes	**NO**

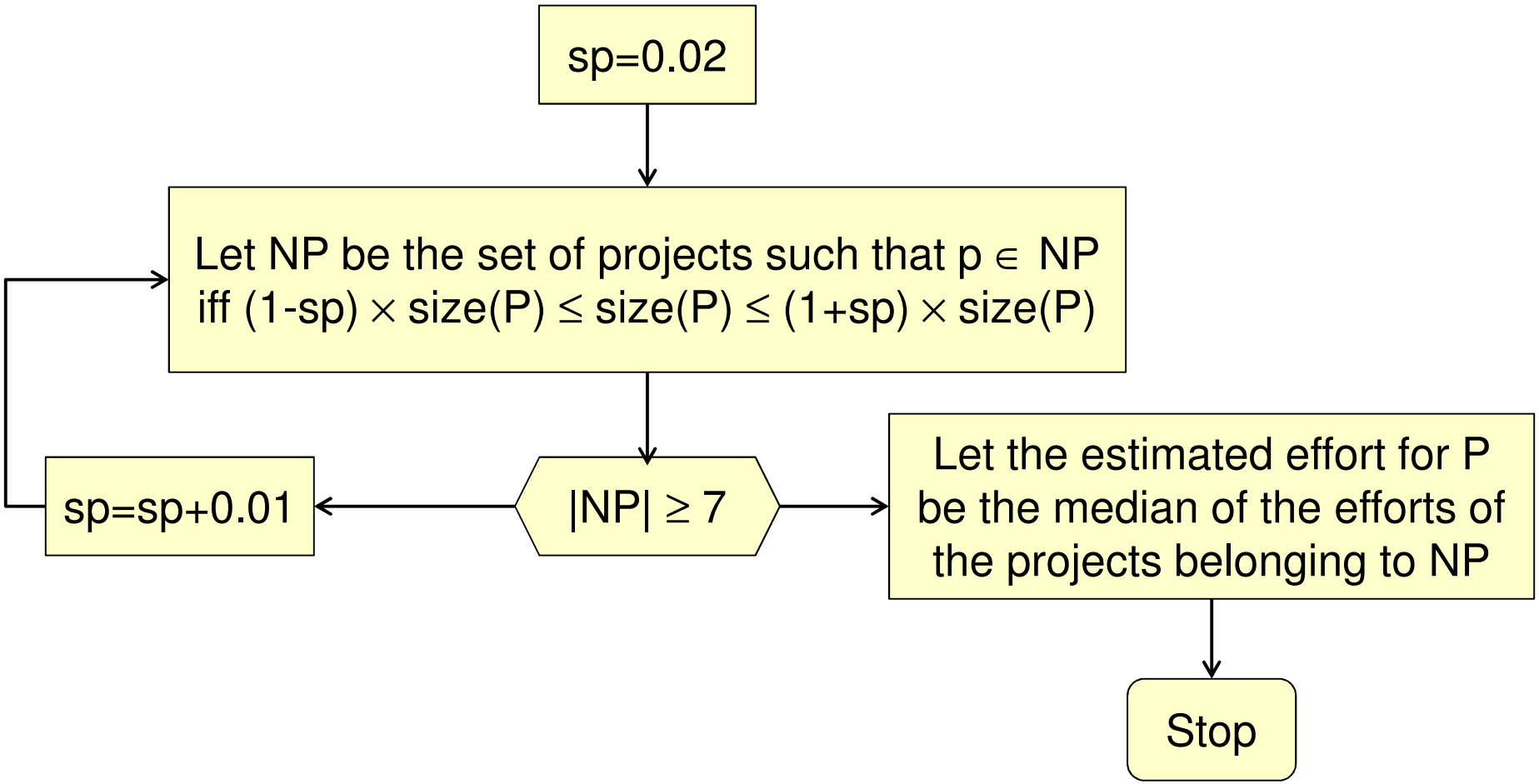
OLS log-log models for New development and Enhancement projects



OLS models are qualitatively similar to the lowess curves

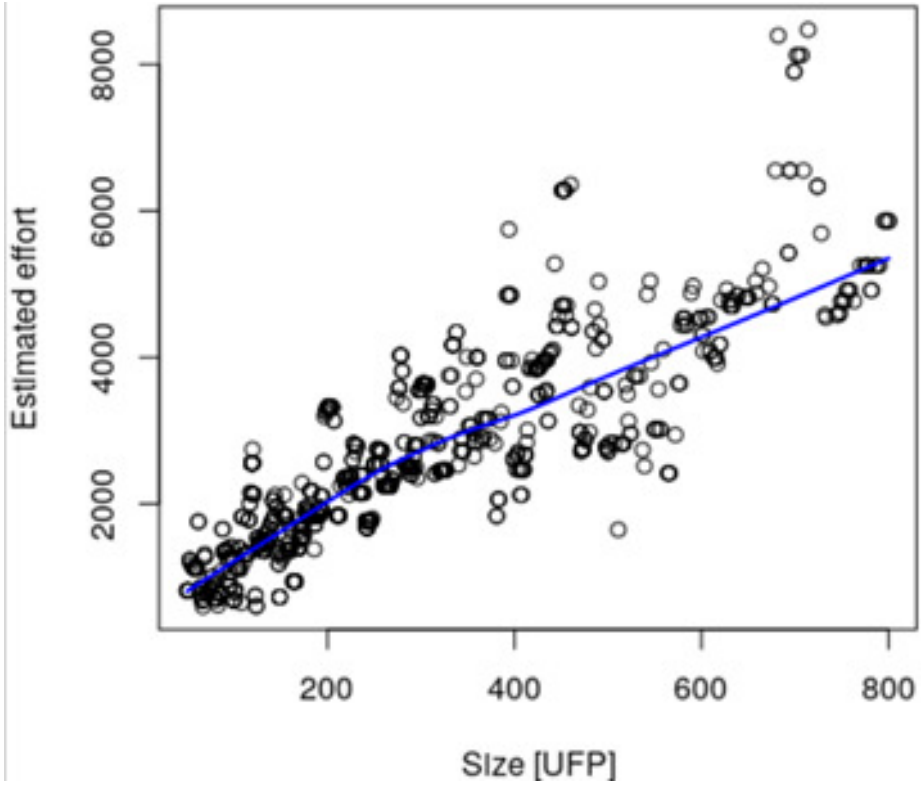
Estimation by analogy

The algorithm used to estimate the effort needed for project P

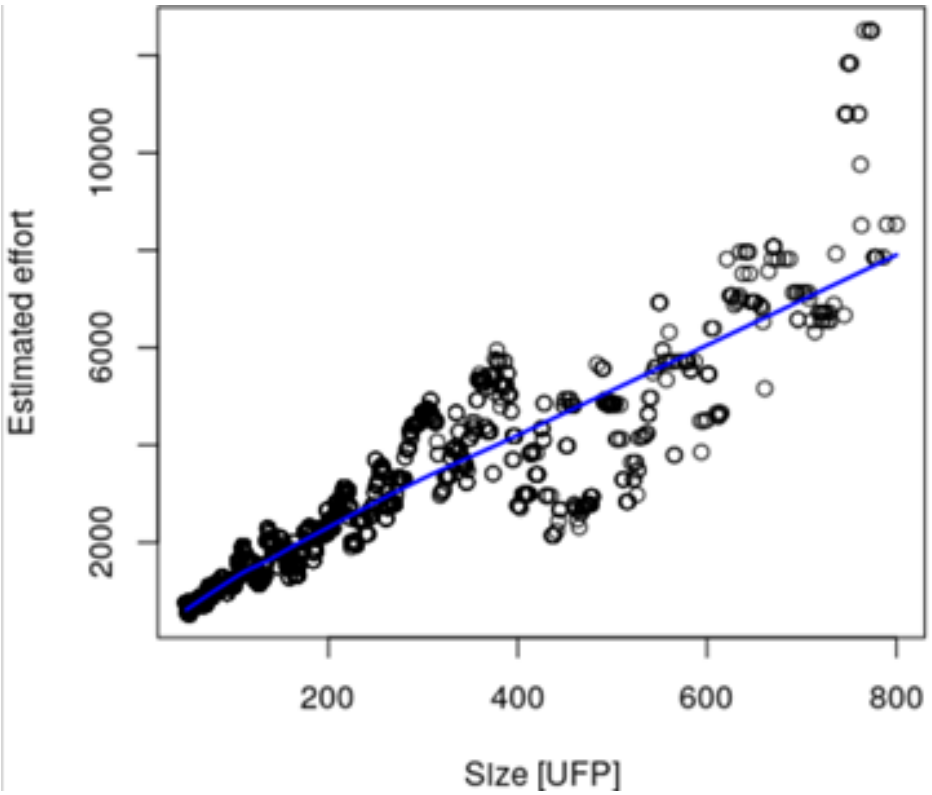


EbA results

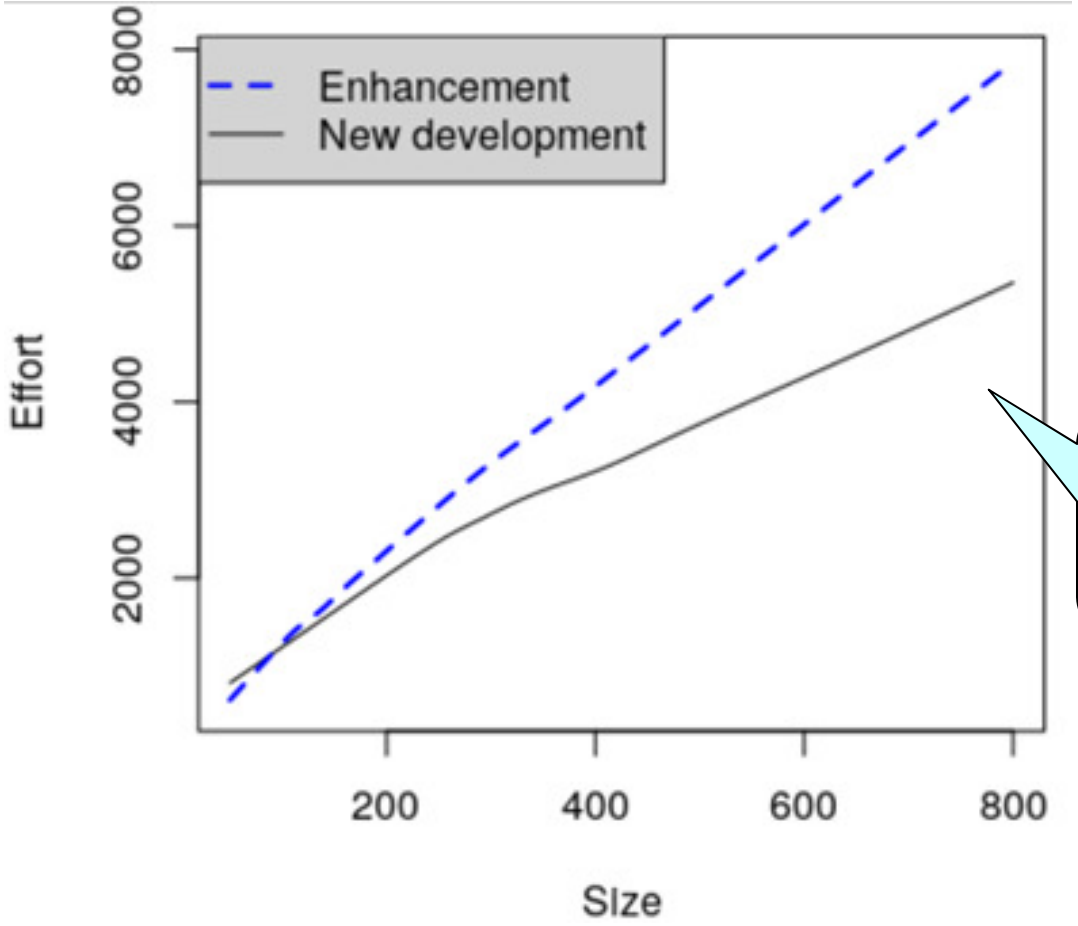
New development projects



Enhancement projects



EbA: comparison



EbA models are qualitatively similar to OLS models and the lowess curves

Conclusions

- Not all the results we presented here are perfectly reliable from a statistical point of view.
- Nonetheless, the consistency of results we obtained via different analysis techniques seems to show that the indications we derived are–at least qualitatively–correct and acceptable.

Conclusions

- Enhancement projects have a unitary cost that appears generally greater than new development projects.
- Specifically, the unitary cost of enhancements and new developments is similar for projects up to around 300 FP, while for larger projects the unitary cost of enhancements is greater.
- The actual unitary cost is largely variable, even for projects having approximately the same size. Therefore, the data presented here must be regarded as indicating tendencies, but are not necessarily valid for all projects.
  - practitioner should be careful in using the productivity values presented in this paper: they should take into account some variability.

Conclusions

- From the cognitive bias point of view, our empirical study showed that
  - the assumption that productivity is higher for functional enhancement projects than for new development projects is not supported by evidence.
  - the opposite appears true, except for fairly small projects.
- We may thus state that–most likely–many huge contracts have been undervalued for years because of an apparently reasonable assumption, not confirmed by empirical data.

Future work

- Future work include, among other activities
  - looking for factors that let us select project classes characterized by small variations in unitary cost
  - experimenting with different techniques for building effort models
- If you have data and want to analyse them, we are ready to cooperate!

Questions?

Thanks for your attention!