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Efficiency Ratios as a Method for Reviewing Statistical Computing Environment Key Performance Indicators

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ABSTRACT

Efficiency ratios are used extensively to measure business and operational performance in many sectors, for example, by financial analysts to determine key aspects of a company's performance. They are easily calculated, simple to understand, and give clear insights into an organisations efficiency. They also offer a uniform method to compare and contrast the performance between different organisations or groups or tasks. This paper describes how efficiency ratios can be used to review both internally (within operations), and externally (between operations), the effectiveness and performance characteristics of various aspects of managing the statistical computing environment (SCE).

INTRODUCTION

An important part of managing any operation is to have a clear objective view of its efficiency. The pressures on statistics and programming departments to perform optimally with regard to time, cost and quality requires management metrics (key performance indicators, KPI) to be in place to support the day-to-day operations.

Typical metrics are often "time-to" measures (time to create and confirm a program, time to study report available etc.), "number-of" determinations (number of errors in data) or review "compliance" related requirements (passed/failed SDTM validation checks). Characteristic of these metrics is that they are measured and reported in the original units of measurement. Whilst knowledge of the absolute values of each metric is clearly valuable (e.g. it took us 15 working days to complete the study's TFLs coding), they do not offer directly any insight into whether this was actually efficient; the plan may have been to complete this work in 10 days (study A) and in 20 days (study B), giving rather different views on overall performance in each case.

Efficiency ratios offer a complementary approach to reviewing and evaluating operations' performance. Their properties enable additional insights into operational efficiency to be gained, and offer approaches to summarising, uniformly presenting and comparing and contrasting metrics, that adds extra management insight beyond that provided by traditional KPIs.

EFFICIENCY RATIO

Task efficiency ratio e_{tsk} can be defined as

$$e_{tsk} = a_{tsk} / p_{tsk}$$

where p_{tsk} is the planned task value and a_{tsk} the actual task value, and is unitless.

BASIC SCE EFFICIENCY RATIO EXAMPLES

Three efficiency ratios of interest to SCE operations are presented below, and illustrate the use of these metrics to review examples of basic key performance indicators that are regularly of SCE concern.

1: Dataset (or Programming/Coding) Efficiency. By determining the number of versions a program goes through before accepted as complete versus the expected number, e_{ds} is defined as $a_{ds\text{-}versions} / p_{ds\text{-}versions}$. This is an

example of a quality metric (see later) where the planned value $p_{ds\text{-}versions}$ might be set to 2 (one development version, one QC version as per the programming practice). A failed QC step resulting in an additional development version would, for example, give an efficiency ratio for the task of 1.5.

2: Specification Hours. Planned resource hours can be used as a surrogate cost measure. For example, resource planning may allocate 16hr for specification development, whilst time recorded shows an additional 4hr was required, giving an overall efficiency ratio, $a_{spec\text{-}hrs} / p_{spec\text{-}hrs}$, of 1.25.

3: Task Completion Efficiency. Planned task timelines efficiencies can be reviewed simply by comparison of the planned and actual durations for a job, e.g. 7day planned, 14day elapsed will give $e_{timeline} = 2$.

TARGET EFFICIENCY RATIO

The optimum or target efficiency ratio (indicative of optimal operational efficiency per plan) is 1.0 (or <1.0). Values greater than 1 indicate less than planned efficiency; less than 1 better than planned. In practice, achieving 1 may not be reasonable, the target efficiency ratio for a specific task should not *de facto* be 1; achievable ratios should be established based on informed consideration of the task being reviewed, and for example, might purposely be set at values >1 to recognize expected overall performance.

It is also important to recognize that the rate of approaching or exceeding 1.0 is dependent upon the value of p_{tsk}. Figure 1 below the relationship between e_{tsk} and a_{tsk} for various values of p_{tsk}. If used to establish a target proportional improvement in efficiency, then care should be taken to establish a range of p_{tsk} values to which this will apply; a change in a_{tsk} of ± 1 results in different degrees of change in e_{tsk} as p_{tsk} varies.

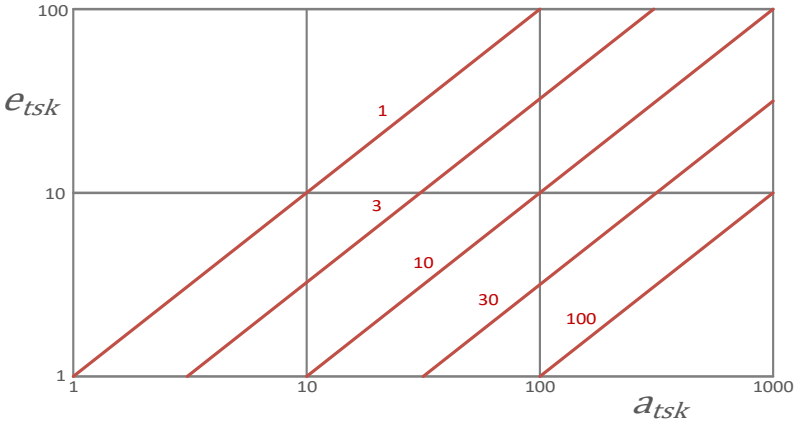


Figure 1:

Graph of e_{tsk} vs a_{tsk} showing the relationship between the rate of approach to e_{tsk} <= 1 for values of p_{tsk} between 1 and 100.
(note log scales)

SCE EFFICIENCY RATIO KPI EXAMPLES

This section presents five SCE related examples of how efficiency ratio can be used as SCE KPIs in support of day to day operations.

TRAINING PROGRESS

Efficiency ratios can be used to determine training progress independent of skills and experience levels using suitable easily determined metrics such as Planned vs Actual Code Reviews or Expected vs Actual Completion times. By establishing initial (immediately post training) expectations and target values to be achieved within a given time frame, simple comparable metrics can be established.

Training efficiency ranges: $e_{initial} = 1.4 - 1.6, e_{target} = 1.2 - 1.3$
SDTM Training – New Hire: $e_{initial} = 6/3 = 2, e_{week1} = 4/3 = 1.25$

STUDY ARTEFACT SPECIFICATION

Efficiency ratios can be employed to provide a consistent approach to reviewing study artefact specification changes. For example, once a protocol and SAP are available, the number of expected TFLs will be known or can be determined. At study end the actual number required will be available; potentially different to original expectations due to protocol amendments or new reporting requirements. Calculating e_{TFL} will then reflect specification efficiency e.g. $p_{TFL} = 42, a_{TFL} = 57, e_{TFL} = 1.36.$ This metric can be usefully used to compare between studies (where absolute TFL numbers will differ), e,g. $p_{TFL} = 98, a_{TFL} = 135, e_{TFL} = 1.37,$ demonstrating, in this case, similar specification efficiency.

COMBINATION RATIOS

Combining efficiency ratios into one overall ratio can provide useful summary management metrics. Here a combination ratio, e_c will be calculated as

$$e_c = \sum e_i / n \ \ (i = 1..n)$$

where e_i are the values for each contributing metric as determined earlier.

For example, relative CRO study delivery efficiency might be determined as the combination of n-Required vs n-Accepted datasets (quality), Contract vs Invoiced Values (Costs) and Planned Duration vs Time to Signoff (time), and used to review between CRO work.

Quality:	36/20	Accepted/Required Datasets	
Cost:	£15.2/15.0	Invoice/Contract Value	
Time:	42d/28d	Actual Duration/Planned Duration	

$$e_{CRO} = (1.20 + 1.01 + 1.5)/3 = 1.24$$

PROCESS EFFICIENCY REVIEW

The overall performance of a process can be effectively presented using efficiency ratios to provide a uniform and consistent method to compare each step in the process. Figure 2 shows schematically the PhUSE KPI phase-1 metrics (in red) developed by the KPI Working Group to support SCE operations over the lifetime of a study and submission to a regulatory agency.

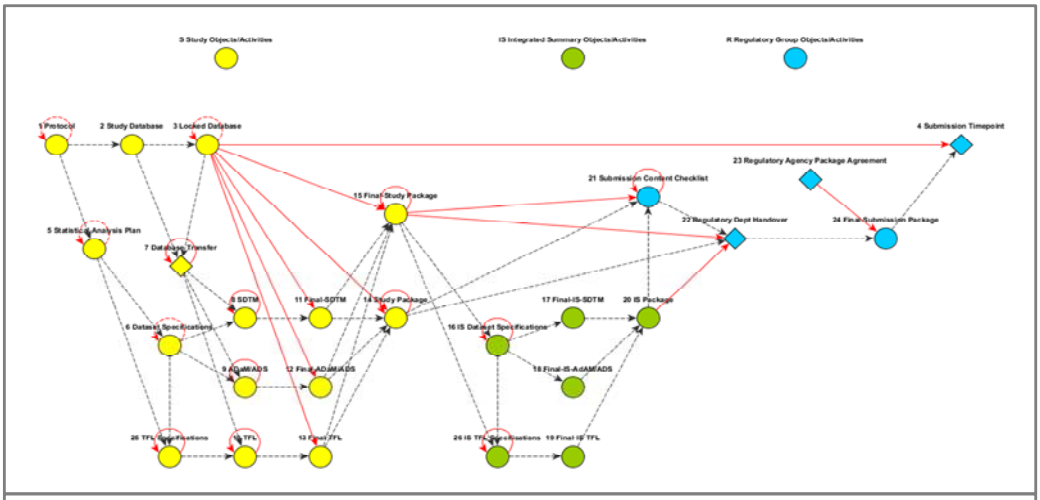


Figure 2

Figure 3 shows and example of how efficiency ratios can be used to review both the overall progress, and the individual efficiency, of each step in the development and use of SDTM datasets for a study. The leftmost block shows the set of quality efficiency ratio metrics based on the number of versions of each artefact, whilst the right-hand block shows two duration efficiency measures, based on the study planned and actual outcomes.

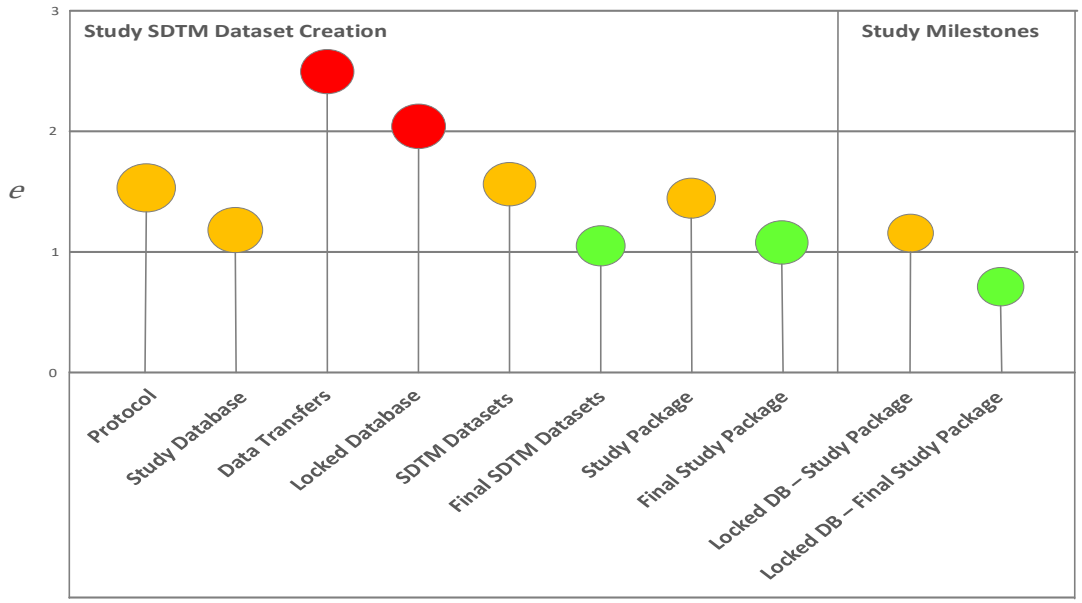


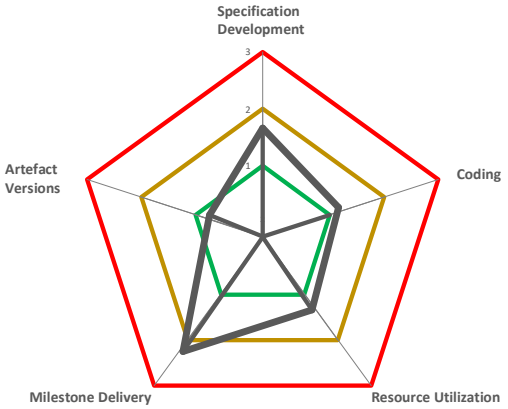
Figure 3

This (fictional) example shows that many more data transfers were required than planned, and that unlocking the database was required (once, it is assumed) to resolve data issues presumably detected during the SDTM creation step, which in its turn was less efficient than planned. However, this was not accompanied by any significant impact directly on the timelines; in the example, the final study package was signed-off in less time than planned.

DEPARTMENTAL OPERATIONS

Efficiency ratios can be used very effectively to support departmental operations as they provide a uniform and consistent method to present and review KPI metrics at any level of management. The radar chart shown in Figure 4 (opposite) is an example of how KPI metrics might be combined for presentation into a "dashboard" style review tool.

Five related but independently measured metrics are illustrated covering a range of typical SCE activities. Comparison of each arm of the chart is immediate and consistent.



Here it would appear coding activities and resource utilization are optimal, SCE products are of high quality, requiring less review than planned, whilst specification and delivery times are less than optimal. Extended specification development (time or quality or both?) might be the cause of poorer milestone delivery value, and would merit further investigation.

DISCUSSION

Efficiency ratios, calculated based on planned versus actual activity, offer a useful alternative to standard performance metrics for reviewing SCE operational effectiveness. They can be applied ubiquitously, are easy to interpret, and can be used consistently to present KPI information to any level of management. Since they are neutral they also offer a simple method to compare between similar operational activities with different absolute measures; reviewing study delivery or CRO deliverables are examples discussed here. They may also be of value supporting initiatives such as those under development by the PhUSE KPI Working Group, where a key objective is to provide an industry benchmarks against which individual operations can be compared

Their use within the organization however, needs to be balanced against the overheads associated with obtaining them. Their operational value needs to be balanced against the administrative burden of collecting and reporting them, and inappropriate metrics or developing confusing combinations or measures must be considered. Also, since they 'hide' the underlying data, their use always needs to be supplemented by some knowledge of the basic data used to calculate them.

ACKNOWLEDGMENTS

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APPENDIX: POSTER PRESENTATION

Efficiency Ratios as a Method for Reviewing Statistical Computing Environment (SCE) Key Performance Indicators (KPI)

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PP05

Introduction

Efficiency ratios offer an easily calculated, simple to understand, neutral, cross organisational method to review key SCE performance metrics. They can be used to review operational efficiencies in a number of circumstances where traditional metrics may not perform optimally.

Efficiency Ratio

Task efficiency ratio e_{tsk} is defined as

$$e_{tsk} = a_{tsk} / p_{tsk}$$

where p_{tsk} is the planned task value, and a_{tsk} the actual task value. For example:

- dataset development efficiency (versions) [a]

$e_{ds} = a_{ds\text{-}versions} / p_{ds\text{-}versions}$

$= 3 \text{ versions required} / 2 \text{ versions planned} = 1.5$

- specification time estimation (task-hours) [c]

$e_{spec} = a_{spec\text{-}hrs} / p_{spec\text{-}hrs}$

$= 20 \text{ hours to complete} / 16 \text{ hours planned} = 1.25$

- task-completion efficiency [b]

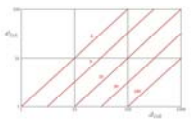
$e_{spec2ds} = a_{spec2ds} / p_{spec2ds}$

$= 14 \text{ days elapsed} / 7 \text{ days planned} = 2$

Target Efficiency Ratio

In all cases the optimum target ratio (best operational efficiency) is **1 (or <1)**, regardless of the absolute values or the units of measurement.

Approaching-Exceeding 1.0



Graph of e_{tsk} vs a_{tsk} showing the relationship between the rate of approach to $e_{tsk} <= 1$ for values of p_{tsk} between 1 and 100

Example-1: Training Progress

Metric:
Planned vs Actual No. of Code Reviews
or
Expected vs Actual Completion Time

ER Ranges:
$e_{Initial} = 1.4 - 1.6$, $e_{Target} = 1.2 - 1.3$

ER Example:
$e_{Initial} = 6/3 = \mathbf{2}$, $e_{week1} = 4/3 = \mathbf{1.25}$

Example-2: Study Artefacts

Metric:
Planned vs Final No. of Study TFLs

ER Example:
Study 1: $p_{TFL} = 42$ (from Protocol & SAP)
$a_{TFL} = 57$
$e_{TFL} = 57/42 = \mathbf{1.36}$

Study 2: $p_{TFL} = 98$ (from Protocol & SAP)
$a_{TFL} = 135$
$e_{TFL} = 135/98 = \mathbf{1.37}$

Example-3: Combination Ratios

Ratios can be combined to give overall efficiencies e.g:

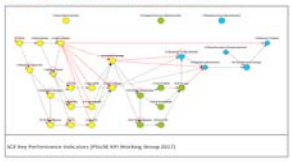
Combine a Quality, Cost & Duration measure

ER Example:

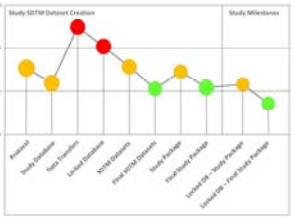
CRO Efficiency
Required vs Accepted Datasets (Quality)
Contract vs Invoiced Value (Cost)
Planned Duration vs Time to Signoff (Time)

(36/30 + £15200/£15000 + 42d/28d)/3
= **1.24**

Example-4: Process Efficiencies



The schematic above shows the proposed phase-I metrics development by the KPI Working Group to support SCE operations, and shows the set of key artefacts and relationships required to report and submit a clinical study. The diagram shows quality and time metrics (as 'versions', and 'from-to' for products)



An example of the overall individual efficiencies of each task providing input to, and subsequent of SDTM datasets, is shown. In this case, it shows that many more data transfers then were planned occurred, and that the database had to be unlocked to, presumably, resolve data issues found during the SDTM step, however study package work thereafter was not significantly compromised.

Example-5: Department Operations

The radar chart below shows an example of how efficiency ratios might be presented to support SCE operations. Five related but independently measured metrics are shown giving an immediate overview of the 'state of the union'. Here it would appear coding, final outputs and programmers' time is optimal, weaker specification efficiency may be the cause of the poor milestone delivery.

Discussion

Efficiency ratios offer a useful alternative to standard performance metrics for reviewing the operational effectiveness of the SCE. They can be applied ubiquitously, are easy to interpret, and provide a neutral method to compare between operations or organisations.

In combination they can be used to summarise efficiencies based on otherwise disparate measures, for example, to review effectiveness over the whole study lifecycle using a common set of metrics such as those being developed by the PhUSE KPI initiatives.

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