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Special Analysis Report

The Impact of Team Size and Software Size on Project Delivery Rate

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Executive Summary

Team size and software size are known to be important factors that affect project delivery rate (PDR-expressed as the number of hours it takes to deliver a function point of functionality). An analysis of ISBSG data shows that these are the two most important factors.

In this report we look at the impact that both team size and software size have on PDR after allowing for the effect of other factors that significantly impact PDR, namely platform and language and we provide data that you can use to produce more accurate estimates by taking these factors into account.

Platform and language are important factors for characterising the environment in which a project is developed. PDR values for different combinations of platform and language are provided in Tables 2 to 6.

Table 1 summarises residual project delivery rates for different combinations of maximum team size and software size, after the effect of language and platform has been taken into account. This table is based on analysis of 508 of the 1,681 projects analysed in this report, for which language, platform, software size, and maximum team size are all known.

The data analysed here suggests that PDR gets worse as team sizes increase, but PDR improves as functional size increases. While these factors are clearly not independent (larger projects tend to have larger teams) you can study Table 1 to gain an understanding of each factor separately as well as together. This table shows the team size adjustment that can be made to a PDR that has been derived from language and platform combined.

Team Size	Software Size (UFP)	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	3 to 200	99	–19.6	–14.1	–11.1	–6.7	–1.7	7.6	55.1	–4.1	12.2
1 to 4	201 to 400	25	–19.8	–14.2	–11.7	–5.1	–2.1	3.3	14.6	–5.3	7.8
1 to 4	401 to 600	5	–18.8	–	–10.3	–9.1	–7.4	–	–3.6	–9.8	5.6
1 to 4	601 to 800	–									
1 to 4	801 to 1,000	2									
1 to 4	More than 1,000	–									
5 to 8	3 to 200	91	–17.0	–10.7	–4.7	–0.2	5.2	19.3	59.5	2.1	12.8
5 to 8	201 to 400	53	–14.8	–12.0	–8.3	–5.4	0.2	6.3	54.5	–2.2	11.6
5 to 8	401 to 600	16	–15.9	–12.9	–12.1	–6.3	–3.6	–0.7	0.8	–7.3	5.3
5 to 8	601 to 800	14	–15.6	–12.2	–10.6	–8.1	–5.9	–4.3	–3.3	–8.5	–3.5
5 to 8	801 to 1,000	3									
5 to 8	More than 1,000	4									
> 9	3 to 200	44	–5.0	–1.0	2.0	11.0	22.2	44.4	59.7	15.5	17.3
> 9	201 to 400	67	–16.9	–9.8	–2.9	1.9	14.4	27.3	36.9	5.3	13.5
> 9	401 to 600	23	–17.5	–12.9	–8.6	0.5	5.8	20.0	224.0	0.5	11.6
> 9	601 to 800	22	–20.0	–13.2	–6.4	–0.5	0.7	5.2	17.7	–2.1	8.4
> 9	801 to 1,000	9	–14.0	–	–6.1	–3.6	–3.2	–	9.8	–3.9	6.4
> 9	More than 1,000	31	–17.9	–14.4	–7.9	–4.8	–0.9	1.6	13.6	–4.9	6.5

Table 1: Effect of Maximum Team Size and Software Size

As you would expect small teams do not develop large projects (Table 1 does not present statistics for samples of fewer than five projects, because the sample is simply too small).

We can use Table 1 to identify the average effect of maximum team size and software size. We do this by looking at the averages. Both median and mean are worth considering - Table 1 shows that projects with a functional size of up to 200 UFP and a maximum team size of 1 to 4 have an average project delivery rate that is 6.7 hours per UFP lower than the overall average, once language and platform have been taken into account. If we consider means, the difference is 4.1 hours per FP, instead of 6.3 hours per UFP.

For example, suppose you start with an estimate of project delivery rate for a given project, based on its platform and language (see Tables 2 to 6). If its size is up to 200 UFP and you expect to use a development team of 1 to 4 people, you could lower your estimated project delivery rate value by 4 to 6 hours per UFP. For a similar functional size but with a team size of 9 or more, you could raise your estimated PDR value by 11 to 15 hours per UFP. Other combinations of functional size and team size have different effects, as shown in Table 1.

The variation increases as team size and software size increase. For example, for 80 percent of the projects with a functional size up to 200 UFP and a team size of 1 to 4, the residual PDR ranges from –14.1 to +7.6 hours per UFP (these are the P10 and P90 values). This is a spread of 21.7 hours per UFP. For teams of 5 to 8 the corresponding spread is 30.0 hours per UFP, and for teams of 9 or more the spread increases to 45.4 hours per UFP. Similar trends can be seen for other variations in team size and software size. The low end (the minimum and P10 values) changes less than the high end (P75 and P90) as team size increases, and the high end gets progressively worse as team size increases.

Broadly, as team size increases PDR deteriorates. As functional size increases PDR tends to improve. As both increase, individually and together, PDR becomes more variable.

Table of Contents

Project Delivery Rates by Category

The following tables are based on analysis of 1,681 projects, out of the 5,052 projects in Release 11 of the repository. These projects all have a high data quality rating (A or B), size measured with IFPUG or NESMA function points, and normalized work effort at resource level 1 (development team only). Extreme outliers are not included. Projects completed more than ten years ago are not included.

The ranges of project characteristics are as follows:

- All are sized with IFPUG function points, version 4 or later, or are new developments sized using the NESMA approach.
- All have high data quality rating (A or B).
- 25 <= Size (UFP) <= 4,200 FP.
- 80 <= Effort <= 61,500 hours.
- Maximum team size <= 52.
- 0.5 <= Duration < 34 months.
- 0.65 <= PDR <= 80 Hrs/FP.
- 4.5 <= Speed of delivery (for the entire project team) < 520 FP/month.
- 0.7 <= Speed of delivery (per project team member) < 45 FP/month/person.
- Project completion date is 1999 or later.
- (Normalized effort for development team / reported effort for development team) < 1.25.

Presentation of Statistics

This section briefly describes the tables in this report. Each table indicates the number of projects represented (N). This number is important, because care must be taken not to draw unwarranted conclusions from small samples of projects.

In the tables that follow, no group of projects is tabulated in its own right unless N is at least 10 (that is, at least 10 projects are represented in every group).

The total number of projects in each table varies. This is because the values of a number of variables are not known for projects submitted to the repository, (that is, submitters do not provide data for every field).

Small inconsistencies between numbers of projects tabulated are due to missing values of variables selected for tabulation; for example, in some cases in the repository the Development Platform is given as "Unknown."

Note: When you are using the tables, always check the number of projects represented. Don't jump to conclusions based on a small number of projects.

Explanation of Tables

In this report, tables are frequently used to summarize some key statistics about the data for the topic being analysed. The following header is common to all of the tables presented:

N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev

- N is the number of projects or data instances in the sample.
- Min is the minimum value found in the sample.
- P10 is the 10th percentile and is that value which is greater than the values of 10 percent of the members of the sample.
- P25 (often also written as Q1) is the 25th percentile or first quartile. It is that value which is greater than the values of 25 percent of the members of the sample or subsample.
- Median (sometimes written as P50) is the middle value; half the values in the data sample or subsample are below this value, while the other half are above it.
- P75 (often also written as Q3) is the 75th percentile or third quartile. It is that value which is greater than the values of 75 percent of the members of the sample or subsample.
- P90 is the 90th percentile and is that value which is greater than the values of 90 percent of the members of the sample or subsample.
- Max is the maximum value found in the sample.
- Mean is the arithmetic mean or average.
- Std Dev is the standard deviation.

Use of the Statistics

In most cases we have focused upon the median rather than the mean. However, the mean is always noted in addition to the median. The median is the more useful measure when the data contains outliers or when it is strongly skewed.

Note: Mean is the average of all the values. Median is the middle value of all the values.

Using the mean or average can be misleading when the data is skewed. One huge number can distort the mean, so that it is no longer a fair representation of "average." This is common in software engineering data sets, so the median is usually preferred.

Standard deviation is a measure of how wide the spread of values is. A small standard deviation means that most numbers fall into a narrow band around the average, and a large standard deviation means there is a wide range of values. A small standard deviation is better for estimation than a large one.

Project Delivery Rates

Project delivery rates in the following tables are expressed in terms of hours per function point.

Programming language	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
ABAP	23	4.2	7.0	7.9	11.3	15.6	21.4	34.3	13.0	7.5
Access	10	1.6	2.4	2.7	7.1	8.7	13.0	14.5	6.8	4.5
ASP	22	1.8	2.6	3.6	6.7	9.9	15.6	30.6	8.6	7.0
Assembler	12	3.8	4.6	8.2	15.7	23.0	34.8	45.8	17.9	13.2
C	103	1.8	3.6	8.3	13.6	24.4	41.0	76.5	18.8	16.3
C++	80	1.0	4.9	8.2	14.8	31.3	54.2	78.7	23.1	20.0
C#	42	1.9	6.1	9.6	15.1	25.1	39.7	49.8	18.8	12.8
COBOL	199	0.8	4.2	6.7	15.3	28.1	48.6	79.7	21.1	18.4
Cool:gen	17	4.7	5.6	8.2	10.8	16.1	26.9	48.3	14.7	11.3
HTML	10	1.0	3.5	4.3	13.7	22.3	40.3	48.0	17.2	16.2
Java, J2EE	171	1.9	4.8	5.9	8.0	15.6	29.4	74.2	13.3	12.9
Lotus Notes	20	1.2	1.5	2.7	3.7	5.1	9.5	12.2	4.7	3.3
Natural	15	3.4	5.1	5.7	10.2	13.9	25.0	35.3	12.2	9.3
Oracle	86	1.2	3.0	4.7	8.2	15.7	23.8	33.8	11.2	8.4
PL/1	99	0.6	2.9	5.7	16.0	22.9	34.3	61.8	16.9	13.4
PL/SQL	18	0.8	1.3	1.7	4.6	9.7	26.4	42.1	9.4	12.0
PowerBuilder	19	4.2	5.0	6.4	9.3	14.1	18.6	23.6	10.9	5.6
Scripting language	26	1.4	3.7	5.1	7.6	13.2	22.5	61.8	11.7	12.4
SQL	60	2.4	3.9	6.2	11.4	16.7	27.2	55.5	13.5	10.7
Visual Basic	208	0.6	2.4	4.1	8.5	18.1	34.7	69.4	13.5	13.4
Other 3GL	95	4.0	6.7	10.2	14.2	22.5	30.1	43.1	16.8	9.1
Other 4GL	61	3.6	6.0	7.8	9.2	13.2	19.2	35.7	11.6	6.7
5GL	23	6.4	8.5	9.8	16.1	22.2	25.5	37.1	17.1	8.2
Other	125	0.7	2.5	5.3	8.6	15.0	24.1	59.3	11.6	10.2

Table 2: Project Delivery Rate by Language – All Platforms

Programming language	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
C	26	5.6	9.2	11.7	15.5	27.5	42.5	60.4	21.6	15.2
C++	14	5.8	10.7	17.1	32.2	49.6	53.3	75.2	34.3	20.2
COBOL	128	0.8	4.2	7.5	16.8	32.3	54.6	79.7	23.0	20.0
Cool:gen	16	4.7	5.9	8.9	11.5	17.5	27.7	48.3	15.3	11.4
Java	14	3.1	5.1	11.4	18.1	27.4	29.4	31.6	18.1	9.7
Oracle	19	1.2	2.9	4.3	6.6	18.5	29.7	31.7	12.1	10.2
PL/1	77	0.6	2.3	4.2	13.2	22.2	28.5	55.1	14.9	12.2
Scripting language	13	1.4	5.7	9.1	13.2	22.1	29.5	61.8	17.5	15.4
Visual Basic	19	0.6	3.6	18.4	27.4	30.3	38.9	54.6	24.7	13.9
Other 3GL	52	4.8	7.2	10.2	13.3	19.5	31.3	43.1	16.6	9.4
Other	74	0.7	2.9	6.4	10.7	16.0	31.5	52.5	13.9	11.6

Table 3: Project Delivery Rate by Language – Mainframe Platforms

Programming language	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
C	14	3.6	8.4	13.1	15.1	22.4	29.5	34.2	17.6	8.8
C++	20	1.3	3.9	5.1	7.9	15.0	19.0	49.6	11.8	11.3
Java	22	4.2	4.5	7.3	9.3	20.9	60.1	74.2	19.0	21.5
Oracle	11	2.0	3.0	5.8	9.0	14.6	24.4	28.8	11.3	8.6
SQL	30	4.1	5.8	9.6	13.3	20.1	29.2	55.5	16.8	11.8
Other	31	3.5	5.3	7.1	10.5	20.8	33.8	42.1	15.1	10.9

Table 4: Project Delivery Rate by Language – Midrange Platforms

Programming language	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
ASP	11	2.2	2.6	2.7	5.9	7.8	9.5	14.3	6.0	3.8
C++	15	4.0	8.6	9.3	11.4	18.5	27.8	60.1	16.5	13.9
COBOL	18	2.8	4.2	5.2	10.4	19.7	24.0	35.1	12.7	9.4
Java	26	1.9	3.0	5.7	7.7	10.9	19.0	25.3	9.3	6.1
Oracle	16	1.2	2.3	3.7	9.0	13.5	19.8	33.8	10.6	8.8
Visual Basic	48	1.0	1.9	3.2	7.2	9.5	13.8	24.4	7.4	5.0
Other	59	1.0	2.2	3.6	7.3	14.6	25.6	49.8	11.2	11.5

Table 5: Project Delivery Rate by Language – PC Platforms

Programming language	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
ABAP	18	4.2	6.5	7.8	9.6	14.6	20.3	34.3	12.1	7.3
C	11	1.8	1.9	2.2	3.9	10.1	13.0	31.3	7.7	8.9
COBOL	12	3.4	4.7	8.3	20.3	37.8	43.2	49.1	22.8	16.3
C#	34	1.9	5.7	8.0	13.7	22.8	32.2	48.8	16.7	11.1
Java	79	3.1	5.0	5.7	6.4	8.1	11.8	17.1	7.4	2.9
Lotus Notes	14	1.5	1.9	2.9	3.7	5.1	7.8	11.9	4.5	2.8
PL/1	20	8.0	12.5	15.6	20.8	26.8	46.8	61.8	24.9	15.1
PL/SQL	11	0.8	1.4	1.7	4.2	6.7	10.7	14.3	5.1	4.3
Visual Basic	115	0.9	2.5	4.2	8.6	18.6	36.8	60.9	14.1	13.9
Other 3GL	40	4.8	7.8	10.9	17.3	22.7	30.0	38.0	17.8	8.6
Other 4GL	56	3.6	6.0	7.8	8.7	12.5	19.2	35.7	11.3	6.5
5GL	16	6.5	8.8	11.5	17.2	22.0	25.1	31.8	17.4	7.1
Other	54	1.1	3.1	4.8	7.4	10.4	14.8	27.4	8.7	5.7

Table 6: Project Delivery Rate by Language – Multi-platforms

Project Delivery Rate by Maximum Team Size

Here we provide information on the PDRs by team size only (not considering the software size as in Table 1). Chart 1 shows the median PDRs for three team size groups for all platforms combined. It provides an indication of the negative impact of larger teams. Tables 7 to 11 provide a more detailed breakdown of PDRs for individual platform types and combined.

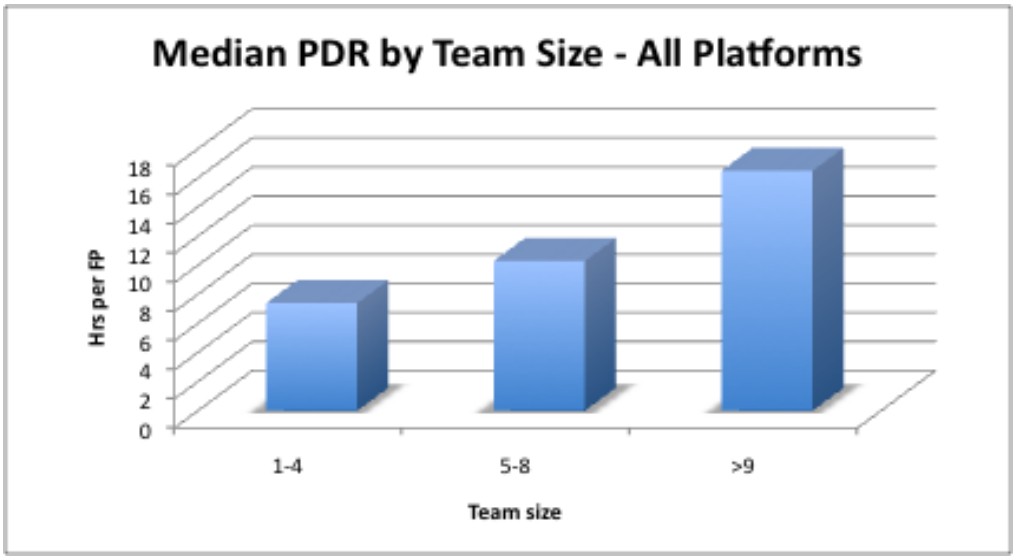

Chart 1: Project Delivery Rate by Team Size Groups – All Platforms

Team size	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	157	1.0	2.9	4.9	7.4	12.4	21.1	77.1	11.0	11.3
5 to 8	212	0.6	3.4	5.9	10.3	16.9	28.0	76.5	13.8	12.4
9 or more	215	0.6	4.2	8.8	16.5	26.9	40.0	78.7	20.0	15.2

Table 7: Project Delivery Rate by Maximum Team Size – All Platforms

Team size	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	41	3.8	5.3	8.0	13.8	21.0	42.0	77.1	19.2	16.9
5 to 8	43	0.6	4.0	8.2	13.6	23.3	47.8	75.2	19.4	17.5
9 or more	45	0.6	2.1	7.5	18.4	27.2	35.3	68.2	20.1	16.1

Table 8: Project Delivery Rate by Maximum Team Size – Mainframe Platforms

Team size	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	6	2.0	–	5.8	6.0	7.4	–	12.4	6.7	3.4
5 to 8	25	3.0	5.1	9.0	11.6	16.8	31.1	45.3	15.3	10.6
9 or more	30	6.8	7.8	11.6	17.0	26.4	30.5	70.2	20.6	13.6

Table 9: Project Delivery Rate by Maximum Team Size – Midrange Platforms

Team size	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	19	1.0	2.8	4.0	6.4	11.2	17.9	42.3	9.7	9.7
5 to 8	35	1.0	1.8	3.5	8.4	11.1	16.8	39.2	9.3	8.7
9 or more	29	1.2	4.2	7.5	9.8	17.6	32.9	49.8	15.0	13.1

Table 10: Project Delivery Rate by Maximum Team Size – PC Platforms

Team size	N	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1 to 4	18	3.9	5.1	5.6	7.5	10.8	18.3	22.9	9.4	5.6
5 to 8	50	1.9	4.6	7.3	8.8	14.0	21.9	41.2	11.4	7.3
9 or more	57	1.1	4.3	10.1	16.6	25.2	38.1	61.8	20.1	13.6

Table 11: Project Delivery Rate by Maximum Team Size – Multi-Platforms

Conclusion

Based on the data, there seems to be a significant difference in productivity rates by maximum team size. Smaller teams can deliver software projects more productively than large teams when developing on midrange, PC or multi platforms. However, on Mainframe platforms, there is no big visible difference between small teams and large teams. Possibly the complexity of mainframe applications is not handled best by small.

The International Software Benchmarking Standards Group

The ISBSG is a not-for-profit organization founded in 1997 by a group of national software metrics associations. Their aim was to promote the use of IT industry data to improve software processes and products.

ISBSG is an independent international organization that collects and provides industry data of software development projects and maintenance & support activities in order to help all organizations (commercial and government, suppliers and customers) in the software industry to understand and to improve their performance. ISBSG sets the standards of software data collection, software data analysis and software project benchmarking processes and is the international thought leader in these practices.

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