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Climbing the SEI maturity model makes a difference on software projects

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ABSTRACT

Using data from 2,500 completed software projects we illustrate the effects of Software Engineering Institute-style software process maturity on duration, effort (cost), and quality. For example, using the median case, in going from SEI software process maturity level 1 to level 2, a typical business application could save 10 months of development time, 75% of development expense, and 75% of development errors. We illustrate additional SEI levels and give some details of the derivation of the mapping of SEI levels to completed software projects.

INTRODUCTION

Using the data base of completed projects established and maintained by Quantitative Software Management (QSM) Inc., which contained 2,500 projects at the time this research was conducted and now contains almost 5,000 project, we were able to map Software Engineering Institute (SEI) Capability Maturity Model (CMM) (Paulk et al., 1993) software process maturity levels to completed projects that had not had SEI-style process assessments. This enabled us to indicate the benefits of achieving increased process maturity on software projects across a large corpus of software project experience.

MAPPING SEI LEVELS TO COMPLETED PROJECTS

The first step in mapping completed project information to SEI process maturity levels is to try to find something in the QSM data base that has a distribution similar to the SEI's process maturity distribution by project. Figure 1 is the SEI distribution for projects by maturity level, and Figure 2 is QSM's distribution of productivity index (PI) (Putnam & Myers, 1992). Note how quickly the SEI maturity level falls off and then note how quickly the QSM PI falls off after a value of, say, 14. Are these two distributions the same, just with different granularity? Are the differences due to chance?

In order to test the hypothesis of similarity, we would have to convert the QSM PI to something that looked more like the SEI distribution by combining several PI values into a single maturity level. There are four ways of doing this:

1. Apply the same distribution of SEI projects by percentage to the QSM projects.
2. Smooth the SEI percentages and apply them to the QSM projects.
3. Use industry experience to combine the QSM productivity indexes into SEI levels.
4. Use a Bayesian technique to assign QSM projects to SEI levels based on odds.

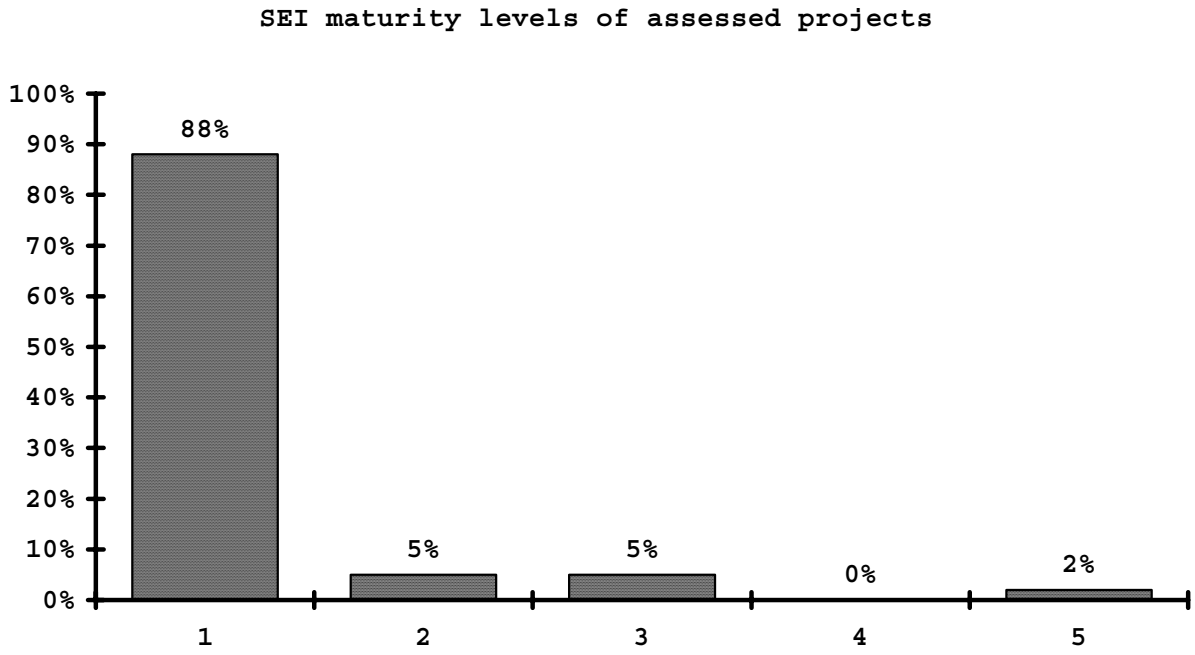

Figure 1. SEI process maturity levels by project for 296 projects.
(Software Engineering Institute, 1991, p. 176)

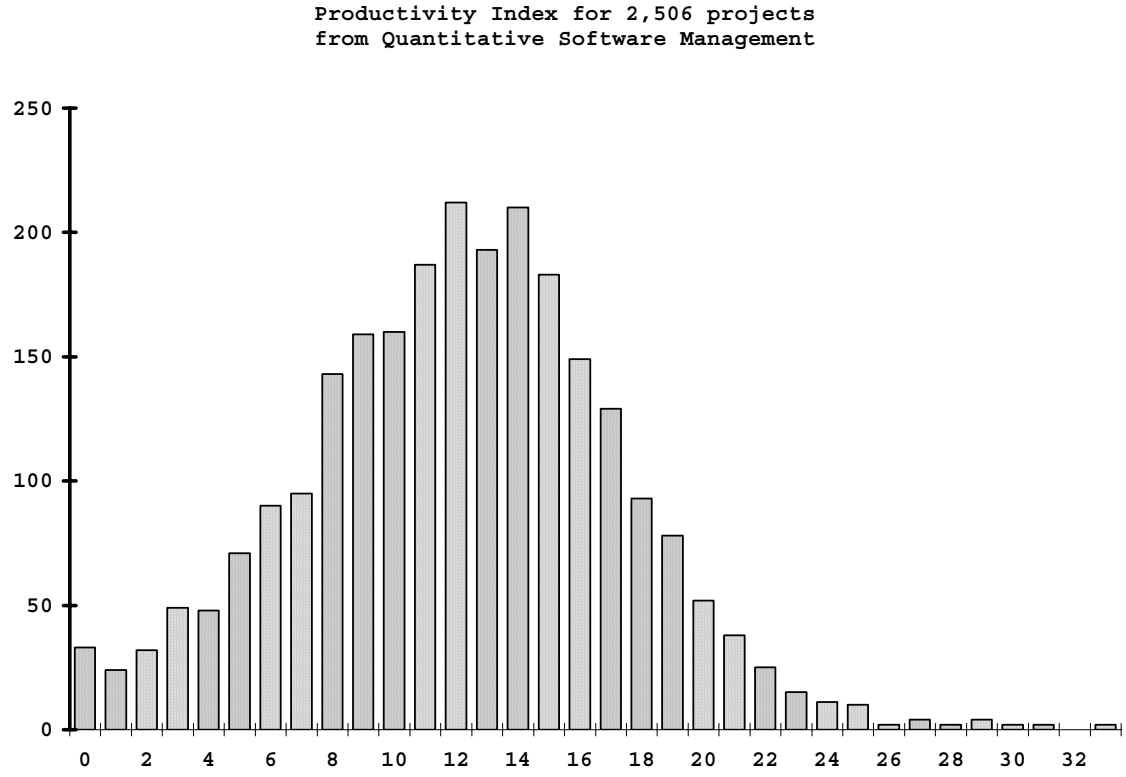

Figure 2. Productivity index for completed projects.
(Adapted from Putnam & Myers, 1992, p. 165)

The fourth method was selected; QSM has applied the third method with results similar to the ones reported here (Putnam, 1996). When one performs the fourth method, one obtains Figure 3. Note that the SEI distribution becomes smoothed using this method of mapping.

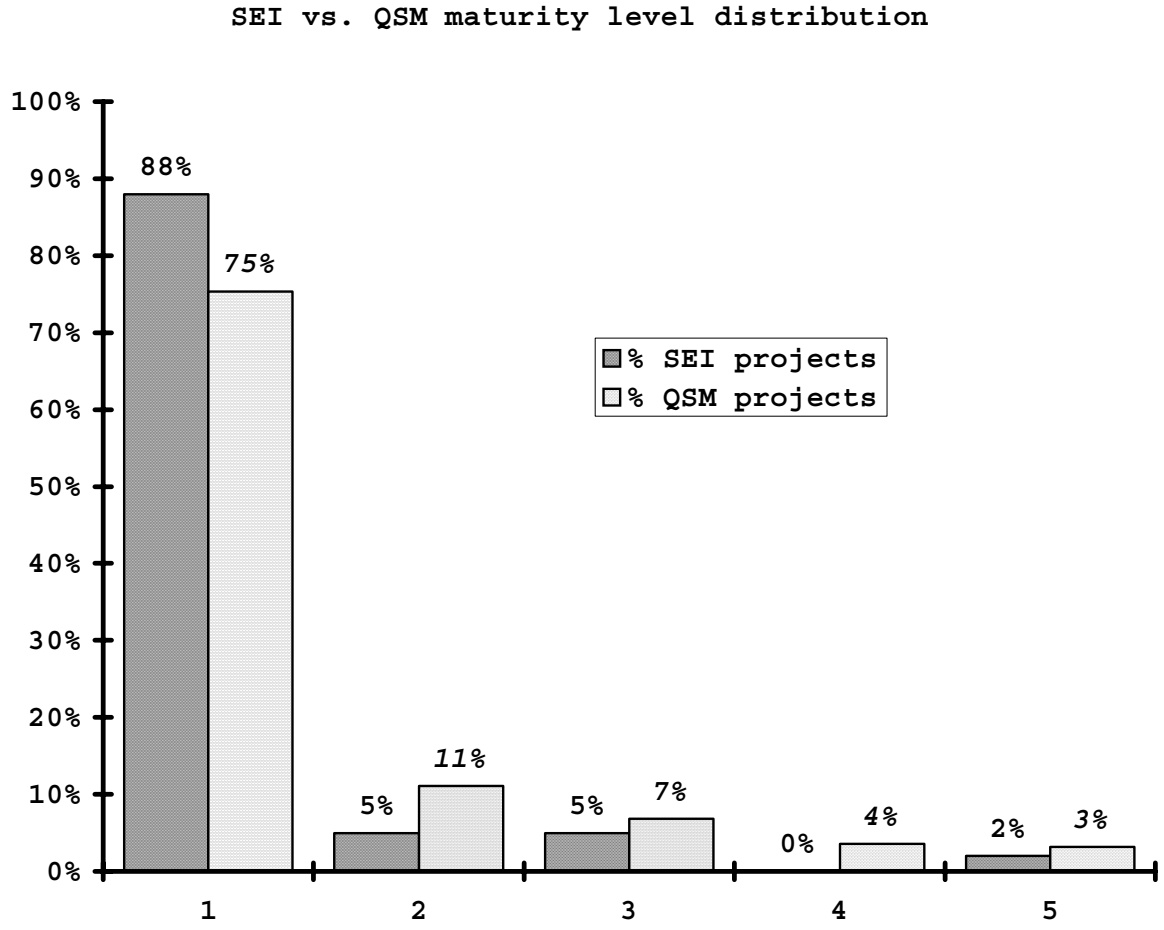

Figure 3. QSM productivity index mapped to SEI process maturity level.

There is still a question of face validity. Even if two distributions can be made to match one another, is there any underlying validity is asserting that one is like the other, is there causal reason to relate the two? Accordingly, we look at the definition of software process maturity and of productivity index to see if there is an underlying relationship.

> *Software process maturity* is the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective. Maturity implies a potential for growth in capability and indicates both the richness of an organization's software process and the consistency with which it is applied in projects throughout the organization. The software process is well-understood throughout a mature organization, usually through documentation and training, and the process is continually being monitored and improved by its users. The capability of a mature software process is known. Software process maturity implies that the productivity and quality resulting from an

> organization's software process can be improved over time through consistent gains in the discipline achieved by using its software process. (Paulk et al., 1993, p. 4)
>
> The *productivity index* … constitutes a macro measure of the total development environment. Low values are generally associated with primitive environments, poor tools, unskilled and untrained people, weak leadership, ineffectual methods …. High values are usually associated with good environments, skilled and experienced people, excellent leadership, effective tools, sound methods …. (Putnam & Myers, 1992, p. 34)

The definitions indicate that each is "everything"! Each definition is almost of an intangible, though detailed, characteristic that is multi-dimensional and runs through all of the aspects of managing and developing software (e.g,, environment, tools, methods, leadership). Accordingly, we accept the informal hypothesis that both software process maturity and productivity index are gross, macro measures, possibly of the same thing. Therefore, the mapping of SEI levels to PI figures is logical.

RESULTS

Below, in Table 1, are the project results for the same project, but at different SEI process maturity levels. The project was constructed to be about 200,000 lines of a business application. There were project data in the QSM data base on 1,300 business applications. The figures are only for the (single) phase that includes low level design, coding, and all testing up to final delivery to a customer in a production setting; this phase is commonly called code and test.

As one can observe comparing level 1 performance with level 2 performance, there is a 10-month reduction in schedule and a 75% reduction in effort (= cost). Also, level organizations have a ratio of highest cost to lowest of just under 100:1. What can account for the 4:1 ratio in effort? I scanned the QSM data base for other information that could explain the ratio. The results are presented below in Table 2.

Project Results by SEI Level

SEI level	Calendar time (months)	Effort (Person months)	Total cost ($ 000)		
			(median)	(lowest)	(highest)
I	29.8	593.5	5,440	1,786	101,721
II	18.5	143.0	1,311	962	1,732
III	15.2	79.5	728	518	933
IV	12.5	42.8	392	279	502
V	9.0	16.0	146	15	271

For the code and test phases only
of a typical 200,000-line business application.

Table 1.

Project Results by SEI Level

(cont.)

SEI level	Calendar time (months)	Effort (Person months)	Defects		Total cost $ 000 (median)
			Discovered	Shipped	
I	29.8	593.5	1,348	61	5,440
II	18.5	143.0	328	12	1,311
III	15.2	79.5	182	7	728
IV	12.5	42.8	97	5	392
V	9.0	16.0	37	1	146

Defect counts include all phases up to final customer shipment.

Table 2.

As the reader can observe, the ratio of discovered defects is 4:1 in comparing level 1 to level 2 (discovery includes injection, discovery, and removal). Note also that there is a ratio of 5:1 of shipped defects (i.e., those discovered by the user). The defects include all categories, not just serious and critical.

CONCLUSION

By mapping SEI process maturity levels to some aspect of completed software projects one can indicate and estimate the effects of software process maturity on project results, which, in the case selected above, is dramatic.

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