

Measuring the ROI of Software Process Improvement

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Software process improvement has been on the agenda of both academics and practitioners, with the Capability Maturity Model¹ as its de facto method. Many companies have invested large sums of money in improving their software processes, and several research papers document SPI's effectiveness. SPI aims to create more effective and efficient software development and maintenance by structuring and optimizing processes. SPI assumes that a well-managed organization with a

defined engineering process is more likely to produce products that consistently meet the purchaser's requirements within schedule and budget than a poorly managed organization with no such engineering process. A sound process is, however, merely one prerequisite: it doesn't guarantee good products. With the amount of attention, literature, and investments focusing on SPI, the question regularly pops up whether these investments are worth their cost.^{2,3} Surprisingly, we find only a limited number of industrial SPI publications that contain cost-benefit numbers and that

measure ROI (see the "ROI Numbers for SPI" sidebar).

Analyzing SPI's ROI is relevant for

- Convincing managers to invest money and effort in improvement, and convincing them that SPI can help solve structural problems.
- Estimating how much effort to invest to solve a certain problem or estimating whether a certain intended benefit is worth its cost.
- Deciding which process improvement to implement first. Many organizations must prioritize due to timing and resource constraints.
- Continuing improvement programs. SPI budgets are assigned and discussed yearly, so benefits must be explicit and organizations must show sufficient ROI, or continuation is at risk.

Software practitioners often say that they can't accurately calculate return on investment because they can't quantify software process improvement's benefits. On the contrary, we can measure benefits just as easily as we measure cost.

ROI Numbers for SPI

You can calculate software process improvement's return on investment by dividing a financial representation of the benefits by a financial representation of the cost. So, an ROI of 5 implies that every invested dollar brings 5 dollars' profit. A limited number of publications contain concrete data for calculating the ROI of SPI. Table A presents an overview of the ROI numbers taken from experience reports in the literature. Not all reports use the formula (benefits – cost)/cost for calculating ROI. Some use benefits/cost or leave out the calculation used. When ROI values are high, the difference is relatively small to the benefit; it's more critical, however, if the ROI approaches 1.

Table A shows that organizations report an ROI of SPI ranging from 1.5 to 19 for every invested dollar (Capers Jones states that he generally observes an ROI between 3 and 30 to every invested dollar¹⁷). The average ROI is 7 and the median of the data is 6.6. Although any SPI undertaking's ROI depends on many influencing factors, it appears that a proper estimation for an SPI ROI lies between 4 and 10.

However, the literature contains limited evidence that these ROIs will occur when you use a specific SPI. The best we can attain with studies focusing only on process factors is strong evidence that SPI is associated with some benefits or that organizations could benefit from SPI activities.¹⁸ Therefore, SPI's benefits will strongly depend on why an organization starts SPI in the first place—what are the intended benefits? Literature findings are diverse and distributed among software engineering's numerous business goals. Furthermore, different SPI approaches have different effects.^{19,20}

Although the publications on SPI's costs and benefits are written by respected researchers and have been through severe reviewing processes, we must consider some limitations to the reported data. Specifically, we must consider the validity of these findings—how good are they and are they generically true?^{18,21} For example, people often report only success stories, not failures, and it's impossible to know how many SPI attempts have failed.

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Table A

ROI numbers in the literature

Context	Return on investment
Unknown* ¹	1.5 (Judith Brodman and Donna Johnson present ROI numbers from several cases: 1.5, 2.0, 4, 6, 7.7, 10, 1.26, 5. Those italicized are probably Tinker, Raytheon, and Hughes Aircraft.)
General Dyn. Dec. Systems ²	2.2
BDN International ³	3 (Sandra Slaughter and colleagues present four ROI numbers: 3.83, 3.65, 2.96, and 2.74.)
Unknown (U) ⁴	4
US Navy ⁵	4.1
Unknown (W) ⁴	4.2
Hughes Aircraft ⁶	5
IBM Global Services India ⁷	5.5
Tinker Air Force Base ¹	6
Unknown (X) ⁴	6.4
Motorola ⁸	6.77
OC-ALC (Tinker) ⁹	7.5
Philips ¹⁰	7.5
Raytheon ^{11,12}	7.72 (This number is calculated based on 6 projects. If the same calculation is followed for the reported 15 projects, this seems to result in an ROI of 4.)
Boeing ¹³	7.75
Unknown (Y) ⁴	8.8
Unknown ¹	10
Hewlett-Packard ¹⁴	10.4
Northrop Grumman ES ¹⁵	12.5 (Donald Reifer and colleagues report an ROI by productivity gains of 1251% on a 5-year planning horizon.)
Ogden ALC ¹⁶	19
Average	7
Median	6.6

*Character used to refer to the respective organization in Herbsleb et al.⁴

Calculating cost and benefits is a prerequisite for investment decision making. This is just as true for SPI as for any other investment.

- Surviving, because any investment in an organization should be valued against its return. Otherwise, money will likely be wasted and you risk bankruptcy in the long run.

Like any change in an organization, SPI is an investment for which the benefits should exceed the cost. One frequent argument in software practice is that measuring SPI's benefits is impossible, or at least difficult. I propose some pragmatic solutions on how to calculate cost and benefits and how to calculate the ROI.

Quantifying cost and benefits: Be pragmatic

Calculating cost and benefits is a prerequisite for investment decision making. This is just as true for SPI as for any other investment. Measuring cost and benefits doesn't have to be difficult. Being pragmatic and involving stakeholders makes quantification easy.

Measuring benefits is as easy as measuring cost

Organizations find it relatively easy to measure cost by measuring effort but have trouble measuring benefits. However, this is owing to a serious misunderstanding of cost measurement: costs are much broader than effort alone. For example, cost also involves other resources, such as office space, travel, and computer infrastructure. Usually when organizations calculate cost they use a fixed hour-rate that they assume acceptably approaches the cost's real value. This is a commonly accepted method. However, such a cost calculation is, in fact, an estimate. In itself, this method isn't wrong. It's a pragmatic agreement on how to approach actual cost with an acceptable accuracy level. However, if we accept that cost measurement is just a matter of estimating and agreeing on the procedure, why don't we do the same for benefits? If (just as with costs) we agree that approaching the actual value is sufficient and we agree on the estimation procedure, we can measure benefits to the same extent as we measure cost.

Measuring benefits is therefore just as easy as measuring cost. We only need to agree on the required accuracy level. Because ROI calculations for SPI don't usually need to be very accurate, we can easily measure benefits based on stakeholder involvement and estimation. Thus, we can incorporate explicit ROI calculations

into SPI investments and evaluate whether the SPI activities were worth the effort.

ROI isn't a strong metric when calculating investments that exceed a one-year time span; in such cases, *net present value* is stronger. However, for this article, I consider only ROI, especially because any industrial investment should show short-term results within the same year.

ROI numbers ease decision making

As I mentioned, detailed ROI calculations aren't necessary. It's usually sufficient to know the ROI's relative value: is it positive, break-even, or negative? In most industrial organizations it isn't as important to know whether the ROI is 7.5 or 9.2; knowing whether it's positive and knowing its range (for example, between 5 and 10) is more than enough for most decision making. The sole reason for calculating ROI is to decide within a specific industrial context (and industry) where to invest the money. SPI is just one possible investment.

The ROI of SPI differs over different situations. For example, a company with severe quality problems at customer sites can obtain a much higher ROI from SPI than a company that wants to increase productivity, because the business benefits are higher in the first case. So, building a business case for SPI is always a specific task for a specific environment. Generic numbers on the ROI of SPI (see the sidebar) can help, but you should build the business case along the lines of the specific context, its goals, and its problems. We can't give a generic benchmark for SPI. However, when building the case for SPI in comparison to other investments, quantifying benefits and ROI will certainly help.

Furthermore, research has proven that humans make trade-off analyses continuously—if not on the basis of objective measurements then on intuition.⁴ Making explicit ROI calculations is therefore crucial for SPI because it's an investment with significant cost and sometimes invisible benefits. The ROI should therefore be visible as well to avoid incorrect intuitive evaluations. Without numbers on SPI's cost, benefits, and ROI, it's impossible to properly decide whether SPI is worth its cost. Even if the overall SPI undertaking breaks even, local benefits might already be worthwhile. For example, if it saves a development team time, then it shortens time-to-market and developers can work faster with less pressure.

To show the ROI of SPI, we must focus on productivity and time-to-market impacts:

The true cost-benefits occur when projects finish earlier, allowing us to apply more engineering resources to the acquisition and development of new business.⁵

Involve stakeholders for benefit estimation

When looking for a basis for measuring SPI benefits, consider that

Although intangible benefits may be more difficult to quantify, there is no reason to value them at zero. Zero is, after all, no less arbitrary than any other number.⁶

So, using a certain number obtained from stakeholder estimation is better than just determining an intangible benefit as zero. Stakeholder involvement for benefit quantification seems logical. Stakeholders see benefits' impacts and values from specific viewpoints. Most people will agree that in practice, it's impossible to find a single person with a full overview on SPI benefits who can also express those in monetary terms.

Multiple stakeholders should therefore be involved. For example, if you know that SPI reduces time-to-market by two weeks, you can ask the marketing department what this will bring in financial values. You will get a number or an estimated range that you can use in your calculations. Also, don't forget to ask the project manager whether the project would have suffered from serious delays if the SPI actions had not been taken—a so-called “what-if-not” analysis.⁶ If so, ask the marketing department what this delay would have cost—another benefit. It's important to include all these SPI benefits and to convert them to a financial value. After all, “money” is a measurement scale that most stakeholders understand.

An alternative to calculating pure cash-flow benefits is to ask those involved (for example, management) what a certain improvement is “worth.” This means not just measuring the effort of the improvement activities but looking at that improvement's value and taking that value as the benefit.

Rather than attempting to put a dollar tag on benefits that by their nature are difficult to quantify, managers should reverse the process and estimate first how large these benefits must be in order to justify the proposed investment.⁶

For example, if a manager states that his or her team is clearly more motivated owing to the SPI initiatives, ask the manager what price he or she would pay for that increased motivation. Ask the manager, for example, how many training days he or she would spend on staff to acquire this increased motivation. If it is, for example, five training days, you can quantitatively estimate this benefit: number of staff × number of days training × (daily rate of staff + daily fee of one-person training). As you see, the benefit is easy to quantify as long as there's agreement on how it's done.

Case studies

I've used the ideas just described in several projects and organizations. I present two case-studies as good practice on how you can do ROI analyses for SPI easily and pragmatically.

A goal, question, metric-based measurement program

My colleagues and I made an initial case for a GQM measurement program. This particular program took place in a systems development department (hardware and software) in an industrial company that produces and services systems for fuel stations. The software team developed an embedded-software product that controls a fuel pump and manages all fuel-transaction communications. This case involves a goal-oriented measurement program that addressed developer distortions (so-called *interrupts*).⁷ The measurement program aimed to find out the reasons for developer interrupts and aimed to reduce them. During a three-month period, a six-person development team measured and improved their processes. Table 1 shows the measurements for this case.

When analyzing the cost, we find this improvement program's total cost was $(320/1600) \times \text{US}\$100,000 = \$20,000$. We made the calculations using 1,600 productive engineering hours per year and a yearly cost of \$100,000 per engineer. (The case took place in the Netherlands.) The software team's effort was 80 hours (\$5,000) and the GQM measurement team's effort was 240 hours (\$15,000). When considering the benefits, we measured that the software team saved 260 hours in engineering effort due to the improvements (reduced number of interrupts). The GQM measurement team saved 60 hours (from reusable material). These benefits related directly to the

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Table 1**Detailed measurements for Case 1's ROI calculation**

Cost-benefits	Value (US\$)	Explanation
Cost		
Engineering team's effort	\$5,000	80 hours' effort expenditure in measurement-program-related tasks, measured from hour-registration system
GQM team's effort	\$15,000	240 hours' effort expenditure for measurement program, measured from hour-registration system
Total cost	\$20,000	
Benefits		
Effort saving due to less interrupts	\$16,000	260 hours' effort saving during the measurement program due to a measured reduction of interrupts ⁷
Effort saving reuse (GQM team)	\$4,000	60 hours' effort saving due to reusable material on interrupt reduction
Total direct benefits	\$20,000	
Early delivery due to effort saving	\$100,000	One-week-early product delivery, measured from value the marketing manager indicated
Effort saving due to spin-off	\$50,000	Effort saving during remainder of the year due to the reduction of interrupts
Increased quality awareness	\$100,000	Increased focus on quality and time expenditure, both in the project as in other groups, measured from value for group manager (combination of buy-in and personal value)
Update of engineering documentation	\$16,000	Some documentation was updated due to a measurable number of interrupts on these documents, measured from value for engineers
Total indirect benefits	\$266,000	
Total benefits	\$286,000	
ROI	1:13	

improvement program's objectives. Therefore, the software team's financial benefits were \$16,000 and the GQM team's were \$4,000. The software team's ROI is therefore 2, and the whole program broke even. We calculate the ROI by dividing the investment's profit by the investment: (benefit – cost)/cost.

However, when we consider the indirect benefits, made clear in the measurement program's feedback sessions and based on the project manager's conclusions, the benefits are higher:

- The project finished at least one week earlier than expected thanks to the measurements (according to marketing, a savings of at least \$100,000).
- Documentation was updated on the basis of the measurement analysis, preventing at least 260 hours of interrupts (equivalent to \$16,000).
- The software team's quality awareness and interruption awareness increased (which the project manager valued at at least \$100,000).
- Interruptions in other projects decreased in the same department owing to increased awareness outside the department (valued at more than \$50,000).

We can calculate the total benefits to be at least \$286,000, making the software team's ROI 55—that is, $(\$286,000 - \$4,000 - \$5,000) / \$5,000$. The whole organization's ROI is

therefore 13— $(\$286,000 - \$20,000) / \$20,000$.

Distinguishing between direct and indirect benefits supports the business case for SPI. The indirect benefits especially (those that are difficult to correlate directly to SPI efforts because they're generated from multiple initiatives) tend to have large financial benefits. Although quantifying those benefits requires some effort, it serves to explain to managers why SPI initiatives support business goals.

The CMM-based improvement program

The second case study presents the results of an ROI evaluation of an industrial SPI program. This program used the software CMM as a starting point for improvement and applied it pragmatically as a checklist for potential improvement actions. The organization develops and services a software simulation package that can execute virtual tests using finite-element modeling. Such simulations give production companies safety feedback on products that are still on the "drawing table." This package's market success is, in fact, mainly due to its high ROI. Imagine the savings for a manufacturer when discovering safety flaws during the design phase rather than the delivery phase.

This particular organization defines its improvement goals in terms of development throughput time, schedule accuracy, and customer satisfaction. After one year in the SPI program, the ROI was evaluated by the SPI

Table 2**Detailed measurements for Case 2's ROI calculation**

Cost-benefits	Value (US\$)	Explanation	Allocation (%)	Value
Cost				
Company effort	\$35,000	305 person-hours with an average hourly fee of \$115, measured from project accounting system	100	\$35,000
External coaching	\$15,000	External coaching hours from consulting company, measured from bills	100	\$15,000
Total cost				\$50,000
Benefits				
Process awareness	\$20,000	Measured from value for R&D manager, through buy-in comparison: 5 days by external trainer	100	\$20,000
Documented processes available	\$160,000	V-model reflected in set-of procedures and standard work breakdown structure for projects; effort saving at least \$4,000 per project, 40 projects per year, measured from value for R&D manager	50	\$80,000
Documentation templates	\$120,000	Buy-in value of good template: \$1,000, 3 templates set-up, 40 projects per year, measured from value for R&D manager and engineers	25	\$30,000
Best practices documented	\$32,000	Effort saving of at least \$800 per project, 40 projects, measured from value for engineers	25	\$8,000
Requirements training followed	\$16,000	Cost of requirements training in effort and external trainer, measured from project accounting system	25	\$4,000
Project documentation updated	\$5,000	Updated documentation based on findings, measured from value for R&D manager	100	\$5,000
Total direct benefits				\$147,000
Project management support	\$650,000	Calculated from value for R&D manager and product manager of the overall set of project management actions (for example, traffic light progress monitoring, customer planning alignment, less late deliveries)	10	\$65,000
Release on time	\$180,000	Effort and cost saving from releasing on time: \$30,000, 6 releases, calculated from value for R&D manager and product manager	25	\$45,000
Role separation	\$255,000	Effort saving of 1.5 person-years, due to role and responsibility separation, measured from value for R&D manager	75	\$190,000
Total indirect benefits				\$300,000
Total benefits				\$447,000
ROI				1:8

consulting company. The approach was undertaken using the pragmatic ideas proposed in the previous section. Available measurements were expanded with five stakeholder interviews (marketing and product manager, development manager, software engineer, test engineer, and release coordinator). These interviews indicated that the SPI program's main benefits were

- Process documentation (description of standard processes, definition of templates and best practices, and a group-wide process-web infrastructure)
- Progress monitoring (periodic reporting by progress metrics and "traffic light" indicators)
- Software engineering role and responsibility definitions
- Improved product documentation

Stakeholders quantified each of these bene-

fits and were asked for effort savings, a value range (between minimum and maximum), or a purchase value ("What if you had to buy this change?"). Every case used the lowest value of the stakeholder numbers, implying that the calculated ROI number was a minimum. One specific addition was made by adding so-called *contribution percentages*. Many improvements couldn't be attributed solely to the SPI program because they resulted from multiple initiatives, so the contribution to the improvement was indicated with such a percentage. Take, for example, the benefit "best practices." Best practices would have probably been documented even without an SPI program. However, the R&D manager estimated that the SPI program had a partial contribution of about 25 percent, owing to the focus on best-practice capturing. In this example, only 25 percent of the value was measured as benefit. Table 2 shows the measurements for this case study.

About the Author



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In the first year, the SPI program cost \$50,000. When measuring benefits, we distinguished between the SPI program's direct benefits (directly attributed to activities in the improvement program) and indirect benefits (results more indirectly attributed to the improvement program). The direct benefits were valued at \$147,000. The indirect benefits were valued at \$300,000. This was calculated from the separate values for project management and control (\$65,000), the on-time release of the product (\$45,000), and role and responsibility definitions (\$190,000).

Based on these collected numbers, it was relatively easy to calculate ROI numbers, using the same formula as the previous case study. The direct ROI was 2 to every invested dollar and the total ROI (including both direct and indirect benefits) was 8. The respective interviewed stakeholders agreed on the numbers underlying these calculations. When presenting them to the complete software engineering team, however, the engineers indicated that they didn't recognize all presented values. Apparently, not everyone was aware of the overall improvements and impacts. We concluded that more intermediate communication on SPI activities and results should have occurred, instead of just one yearly ROI analysis. This could have improved common understanding of the improvement program's benefits for the department.

My colleagues and I will continue facilitating the quantification of cost and benefits for software engineering. We're convinced that more attention for building and evaluating business cases will bring the software engineering discipline to a higher professional level. Quantifying economic aspects should be part of this discipline.

Our work focuses on developing approaches that work in practice while being based on sound scientific theories.

Pragmatic ROI calculations are feasible and easy. Furthermore, they open a discussion on SPI's cost, benefits, and ROI. Pragmatism is crucial—you must apply an approach for measuring cost and benefits that's simple and fast by involving stakeholders. You must also accept that estimating such cost and benefits might not be perfectly accurate, but accuracy isn't the main purpose. The purpose is to indicate value, to indicate whether cost and benefits are balanced, and to obtain an ROI number for communication purposes. Expressing cost, benefits, and ROI in financials is crucial. Different people in different roles always have trouble understanding each other's language. If one generic term exists for which people share perception, it's money. ☺

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