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# *A Systematic Mapping on Productivity Metrics in Software Development and Maintenance*

Edson Oliveira, Davi Viana, Marco Cristo, Tayana Uchôa Conte  
{edson.cesar, marco.cristo, tayana}@icomp.ufam.edu.br  
davi.viana@lsdi.ufma.br

USES – Grupo de Usabilidade e Engenharia de Software  
PPGI – Programa de Pós-Graduação em Informática Instituto de Computação  
Universidade Federal do Amazonas (UFAM) Manaus, AM - Brazil



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# A Systematic Mapping on Productivity Metrics in Software Development and Maintenance

Edson Oliveira<sup>1</sup>, Davi Viana<sup>2</sup>, Marco Cristo<sup>1</sup>, Tayana Conte<sup>1</sup>

<sup>1</sup>USES – Grupo de Pesquisa em Usabilidade e Engenharia de Software – Universidade Federal do Amazonas (UFAM) – Manaus – AM – Brasil

<sup>2</sup>Universidade Federal do Maranhão (UFMA), São Luís – Maranhão – Brasil

{edson.cesar, marco.cristo, tayana}@icompu.fam.edu.br

davi.viana@lstdi.ufma.br

**Abstract.** *Context:* productivity has been a recurring topic, and despite its importance, researchers have not yet reached a consensus on how to properly measure productivity in software engineering. *Aim:* to investigate and better understand how software productivity researchers are using software productivity metrics. *Method:* we performed a systematic mapping study on publications regarding software productivity, extracting how software engineering researchers are measuring software productivity. *Results:* In total, 91 software productivity metrics were extracted. The obtained results show that researchers apply these productivity metrics mainly focusing on software projects and developers, and these productivity metrics are predominantly composed by *Lines of Code (LOC)*, *Time* and *Effort* measures. *Conclusion:* although there is no consensus, our results shows that single ratio metrics, such as *LOC/Effort*, for software projects, and *LOC/Time*, for software developers, are a tendency adopted by researchers to measure productivity.

**Keywords.** Software Engineering, Software Metrics, Software Productivity, Mapping Study.

## 1. Results from the first filter

Id	Year	Criterion	Publication
625	1979	IC-1	Measuring the Psychological Complexity of Software Maintenance Tasks with the Halstead and McCabe Metrics
624	1981	EC-1	Hard-to-use evaluation criteria for software engineering
623	1981	IC-1	Programming measurement and estimation in the software engineering laboratory
622	1981	EC-1	Some issues in the measurement and control of programming productivity
621	1986	EC-1	IMPACT ON SOFTWARE DEVELOPMENT COSTS OF USING HOL'S.
620	1986	EC-1	ITERATIVE DEVELOPMENT OF INFORMATION SYSTEMS: A CASE STUDY.
619	1987	IC-1	COMMENTS, WITH AUTHOR'S REPLY, ON 'IMPROVING SOFTWARE PRODUCTIVITY' BY B. W. BOEHM.
618	1987	IC-1	EVALUATING SOFTWARE ENGINEERING TECHNOLOGIES.
617	1988	IC-1	SOFTWARE DEVELOPMENT PRODUCTIVITY TOOLS AND METRICS.
616	1988	EC-1	Understanding and Controlling Software Costs
615	1989	IC-1	A summary of software measurement experiences in the Software Engineering Laboratory
614	1989	EC-1	An empirical study of COBOL programs via a style analyzer: The benefits of good programming style
613	1989	EC-1	An industrial engineering approach to software development

612	1989	EC-1	Scale economies in new software development
611	1989	IC-1	Software development: state of the art vs. state of the practice
610	1989	EC-1	Technology dependence in function point analysis: a case study and critical review
609	1989	EC-1	Volume, distance and productivity
608	1990	EC-1	A process model for software maintenance
607	1990	IC-1	A study of the impact of C++ on software maintenance
606	1990	EC-1	Getting started on metrics - Jet Propulsion Laboratory productivity and quality
605	1990	EC-1	Hypertool: A programming aid for message-passing systems
604	1990	EC-1	Organizational learning curve in software installation: An empirical investigation
603	1990	EC-1	Quantitative process management in software engineering, a reconciliation between process and product views
602	1990	EC-1	Software metrics in the process maturity framework
601	1990	EC-1	Technology-process fit: Perspectives on achieving prototyping effectiveness
600	1991	EC-1	A stratified blackboard-like architecture for computer-based instruments
599	1991	EC-1	An empirical test of object-based output measurement metrics in a computer aided software engineering (CASE) environment
598	1991	EC-1	Approaches to measuring size of application products with CASE tools
597	1991	IC-1	Cyclomatic complexity density and software maintenance productivity
596	1991	IC-1	Model to evaluate variables impacting the productivity of software maintenance projects
595	1991	IC-1	Predicting (individual) software productivity
594	1991	IC-1	Reuse and productivity in integrated computer-aided software engineering: An empirical study
593	1992	IC-1	CUSTOMIZED SYSTEMS FOR ENGINEERING APPLICATIONS
592	1992	IC-1	Information models of software productivity: Limits on productivity growth
591	1992	IC-1	Productivity analysis of software development with an integrated CASE tool
590	1992	IC-1	Software productivity metrics: who needs them?
589	1992	EC-1	Software reuse economics: Cost benefit analysis on a large-scale Ada project
588	1992	EC-1	THE IMPACT OF UNDERGRADUATE SOFTWARE ENGINEERING-EDUCATION ON ADVANCING CASE TOOLS
587	1993	IC-1	CP-6: quality and productivity measures in the 15-year life cycle of an operating system
586	1993	IC-1	Exploration of the impact of individual and group factors on programmer productivity
585	1993	EC-1	How effective are software engineering methods?
584	1993	EC-1	Is ABC cycle counting a wasteful approach?
583	1993	EC-1	Measurement. The key to application development quality
582	1993	IC-1	On the study of software reuse using reusable C++ components
581	1993	EC-1	Process clustering with an algorithm based on a coupling metric
580	1993	EC-1	Repository evaluation of software reuse

579	1993	IC-1	Software process maturity: measuring its impact on productivity and quality
578	1993	EC-1	Software process modelling and measurement: a QMS case study
577	1993	EC-1	The software product feedback flow model for development planning
576	1994	EC-1	Automating Output Size and Reuse Metrics in a Repository-Based Computer-Aided Software Engineering (CASE) Environment
575	1994	IC-1	CASE-STUDIES OF SOFTWARE-PROCESS-IMPROVEMENT MEASUREMENT
574	1994	IC-1	Effects of Reuse on Quality, Productivity, and Economics
573	1994	EC-1	Evidence on economies of scale in software development
572	1994	EC-1	Impact of object-oriented technology on software quality: three case histories
571	1994	EC-1	Multiple windows, task complexity, and SQA effectiveness
570	1994	IC-1	Perceptions of the benefits from the introduction of CASE: An empirical study
569	1994	EC-1	Software reusability in Australia
568	1994	EC-1	Tool-based quality management in object-oriented software development
567	1994	IC-1	Using Metrics to Manage Software Projects
566	1995	IC-1	Analysis of review's effectiveness based on software metrics
565	1995	IC-1	Analytical and empirical evaluation of software reuse metrics
564	1995	IC-1	Approaches to making software porting more productive
563	1995	IC-1	CHANGE-POINTS: A proposal for software productivity measurement
562	1995	EC-1	Computer-aided software engineering: The determinants of an effective implementation strategy
561	1995	EC-1	Experience with logical code analysis in software maintenance
560	1995	EC-1	Measurement of functional reuse in maintenance
559	1995	IC-1	Method for measuring programmer debugging performance from key strokes
558	1995	EC-1	Metrics-guided reuse
557	1995	IC-1	Neural fuzzy system to evaluate software development productivity
556	1995	IC-1	Personal 'progress functions' in the software process
555	1995	EC-1	Reducing time to market through optimization with respect to soft factors
554	1995	EC-1	Reusing Software: Issues and Research Directions
553	1995	IC-1	Sizing measure for adaptive maintenance work products
552	1995	EC-1	TCB/SRB analysis approach to estimating CPU productivity through fast I/O
551	1996	EC-1	An update on a maturity benchmarking process for electronic design processes
550	1996	EC-1	Analysis of Benchmark Characteristics and Benchmark Performance Prediction
549	1996	EC-1	Assessing the use and effectiveness of metrics in information systems: a case study
548	1996	EC-1	Design principles for the virtual workplace
547	1996	IC-1	Function point sizing: Structure, validity and applicability

546	1996	EC-1	Improving Speed and Productivity of Software Development: A Global Survey of Software Developers
545	1996	IC-1	Measuring productivity of software projects: A data envelopment analysis approach
544	1996	EC-1	Measuring reuse: a cautionary tale
543	1996	IC-1	Programmers' performance on structured versus nonstructured function definitions
542	1996	IC-1	Software development productivity of european space, military, and industrial applications
541	1996	IC-1	The effect of object-oriented frameworks on developer productivity
540	1996	EC-1	Usability metrics: Tracking interface improvements
539	1996	EC-1	Why software reliability predictions fail
538	1997	EC-1	A method for estimating maintenance cost in a software project: A case study
537	1997	EC-1	An analysis of errors in a reuse-oriented development environment
536	1997	IC-1	An empirical study of software reuse with special attention to Ada
535	1997	EC-1	Component libraries for software re-use
534	1997	IC-1	Effect of software structure attributes on software development productivity
533	1997	IC-1	Estimating software development effort with connectionist models
532	1997	EC-1	Evaluating the impact of CASE: An empirical comparison of retrospective and cross-sectional survey approaches
531	1997	IC-1	Experiences introducing a measurement program
530	1997	IC-1	Function points and their use
529	1997	IC-1	Function points and their use
528	1997	EC-1	How software process improvement helped motorola
527	1997	EC-1	How to achieve 7.52 function-points per person-day with object technology
526	1997	EC-1	Introduction to ProcessModel and ProcessModel 9000
525	1997	EC-1	Measuring software engineering evolution: A rasch calibration
524	1997	IC-1	Measuring the performance of a software maintenance department
523	1997	EC-1	Metrics and analyses in the test phase of large-scale software
522	1997	EC-1	Personal Software Process (PSP)SM. A full-day tutorial
521	1997	EC-1	Phase containment metrics for software quality improvement
520	1997	EC-1	Pragmatic software metrics for iterative development
519	1997	EC-1	Processes involved in reading imaging studies: Workflow analysis and implications for workstation development
518	1997	EC-1	Project assessment technology for software production
517	1997	EC-1	Status report on software measurement
516	1998	IC-1	Analyzing effects of cost estimation accuracy on quality and productivity
515	1998	EC-1	Applying GQM in an Industrial Software Factory
514	1998	EC-1	Communication and organization: An empirical study of discussion in inspection meetings
513	1998	EC-1	Introduction to ProcessModel and ProcessModel 9000

512	1998	EC-1	Investments in reusable software. A study of software reuse investment success factors
511	1998	IC-1	Managerial use of metrics for object-oriented software: An exploratory analysis
510	1998	EC-1	Measuring information systems service quality: Lessons from two longitudinal case studies
509	1998	IC-1	Measuring the impacts individual process maturity attributes have on software products
508	1998	EC-1	Q-MOPP: Qualitative evaluation of maintenance organizations, processes and products
507	1998	IC-1	Software development practices, software complexity, and software maintenance performance: A field study
506	1998	IC-1	Software size measurement and productivity rating in a large-scale software development department
505	1998	EC-1	Strategies for intelligent system development
504	1998	EC-1	Structured testing approach for DSP software
503	1998	EC-1	Tailoring cleanroom for industrial use
502	1999	IC-1	A performance measure for software reuse projects
501	1999	EC-1	A software reuse measure: Monitoring an enterprise-level model driven development process
500	1999	EC-1	Aligning strategic and project measurement systems
499	1999	EC-1	Benchmarking COTS projects using data envelopment analysis
498	1999	EC-1	Building reusable software
497	1999	EC-1	Case study in innovative process improvement: Code synthesis from formal specifications
496	1999	IC-1	Comparing observed bug and productivity rates for Java and C++
495	1999	EC-1	Costs and benefits of reuse
494	1999	IC-1	Empirical evaluation of reuse sensitiveness of complexity metrics
493	1999	IC-1	Framework based software development: Investigating the learning effect
492	1999	EC-1	Geometrical and statistical foundations of a three-dimensional model of software performance
491	1999	IC-1	Measuring functionality and productivity in Web-based applications: A case study
490	1999	EC-1	Micro-process based software metrics in the training
489	1999	IC-1	Neural networks for software metrics estimation
488	1999	EC-1	Performance evaluation of general and company specific models in software development effort estimation
487	1999	IC-1	REMEX - A case-based approach for reusing software measurement experienceware
486	1999	EC-1	Scenario based integration testing for object-oriented software development
485	1999	EC-1	State of practice in the use of software metrics
484	1999	EC-1	The impact of goals on software project management: An experimental investigation
483	2000	EC-1	A software process improvement support system: spis
482	2000	IC-1	Algorithmic cost estimation for software evolution
481	2000	IC-1	Benchmarking software development productivity
480	2000	EC-1	Berkeley Project Management Process Maturity Model: Measuring the

			value of project management
479	2000	EC-1	Beyond productivity in software maintenance: factors affecting lead time in servicing users' requests
478	2000	IC-1	Case study of open source software development: the Apache server
477	2000	IC-1	How does radical collocation help a team succeed?
476	2000	EC-1	Initiation of a Software Reuse Program
475	2000	EC-1	Locality metrics and program physical structures
474	2000	IC-1	Metrics in the development and maintenance of software: An application in a large scale environment
473	2000	EC-1	METRICS: a system architecture for design process optimization
472	2000	EC-1	Personal software process in the classroom: student reactions
471	2000	EC-1	Software development and new product development: potentials for cross-domain knowledge sharing
470	2000	IC-1	Software engineering productivity measurement using function points: A case study
469	2000	EC-1	Software project control and metrics
468	2000	EC-1	Software Project Planning Associate (SPPA): A knowledge-based approach for dynamic software project planning and tracking
467	2000	EC-1	Statistical process control: analyzing a space shuttle onboard software process
466	2000	EC-1	Validating the ISO/IEC 15504 measure of software requirements analysis process capability
465	2000	IC-1	Validating the ISO/IEC 15504 measures of software development process capability
464	2001	EC-1	A method for efficient measurement-based COTS assessment and selection - Method description and evaluation results
463	2001	EC-1	Advances in predictions from wool to yarn
462	2001	IC-1	An empirical study of software productivity
461	2001	EC-1	An experiment measuring the effects of Personal Software Process (PSP) training
460	2001	EC-1	An industrial study of reuse, quality, and productivity
459	2001	IC-1	Assessing massive maintenance processes: An empirical study
458	2001	EC-1	Richards Bay update
457	2001	EC-1	Software benchmarking: Serious management tool or a joke?
456	2001	EC-1	Using reading techniques to focus inspection performance
455	2002	EC-1	A graph-based metamodel for object-oriented software metrics
454	2002	EC-1	A model-based approach to object-oriented software metrics
453	2002	EC-1	Achieving higher levels of CMMI maturity using simulation
452	2002	IC-1	Disaggregating and calibrating the CASE tool variable in COCOMO II
451	2002	IC-1	Empirical analysis of massive maintenance processes
450	2002	EC-1	Measuring OO design metrics from UML
449	2002	EC-1	Measuring software evolution at a nuclear fusion experiment site: a test case for the applicability of OO and reuse metrics in software characterization
448	2002	EC-1	Processes involved in reading imaging studies: workflow analysis and implications for workstation development.

447	2002	EC-1	Rapid software development through team collocation
446	2002	EC-1	Software process decision support: Making process tradeoffs using a hybrid metrics, modeling and utility framework
445	2002	EC-1	Toward CAD-IP reuse: A web bookshelf of fundamental algorithms
444	2002	IC-1	Two case studies of open source software development: Apache and Mozilla
443	2002	EC-1	UML-based performance engineering possibilities and techniques
442	2003	EC-1	A model to evaluate the economic benefits of software components development
441	2003	EC-1	A procedure for assessing the influence of problem domain on effort estimation consistency
440	2003	EC-1	Assessing the maintenance processes of a software organization: An empirical analysis of a large industrial project
439	2003	EC-1	Boost stock performance, nation's economy
438	2003	EC-1	Design, retrieval, and assembly in component-based software development
437	2003	EC-1	Determinants of software volatility: a field study
436	2003	IC-1	Empirical analysis of CK metrics for object-oriented design complexity: Implications for software defects
435	2003	IC-1	Identifying high performance ERP projects
434	2003	EC-1	Quantitative metrics for risk assessment in software projects
433	2003	EC-1	Scenario based testing & test plan metrics based on a use case approach for real time UPS (Uninterruptible Power System)
432	2003	IC-1	Simple metrics for improving software process performance and capability: A case study
431	2003	IC-1	Towards meaningful benchmarking of software development team productivity
430	2003	EC-1	Usability meanings and interpretations in ISO standards
429	2003	EC-1	Work environment and computer systems development
428	2004	IC-1	A field study of developer pairs: Productivity impacts and implications
427	2004	EC-1	A framework for measuring supercomputer productivity
426	2004	EC-1	A performance evaluation framework for a public university knowledge management system
425	2004	EC-1	A real-time monitoring and diagnosis system for manufacturing automation
424	2004	EC-1	A reusable, academic-strength, metrics-based software engineering process for capstone courses and projects
423	2004	IC-1	An exploration of the relationship between software development process maturity and project performance
422	2004	IC-1	An extension of SEMEST: The online software engineering measurement tool
421	2004	IC-1	Are individual differences in software development performance possible to capture using a quantitative survey?
420	2004	EC-1	Data mining for validation in software engineering: An example
419	2004	IC-1	DEA evaluation of a Y2K software retrofit program
418	2004	IC-1	Defining and measuring the productivity of programming languages
417	2004	EC-1	Engineering safety requirements, safety constraints, and safety-critical requirements
416	2004	EC-1	Experimental comparison of the comprehensibility of a Z specification and its implementation in Java



415	2004	EC-1	High performance computing productivity model synthesis
414	2004	EC-1	Interface metrics for reusability analysis of components
413	2004	IC-1	Jackson networks and Markov processes for resource allocation modeling
412	2004	EC-1	Managing coordination and cooperation in distributed software processes: The GENESIS environment
411	2004	EC-1	Measuring high performance computing productivity
410	2004	EC-1	Performance metrics based on computational action
409	2004	EC-1	Precise Call Graphs for C Programs with Function Pointers
408	2004	EC-1	Six sigma for software
407	2004	IC-1	Software productivity measurement using multiple size measures
406	2004	EC-1	Towards a corporate performance measurement system
405	2004	EC-1	Vertical profiling: Understanding the behavior of object-oriented applications
404	2004	EC-1	Workshop on software engineering for high performance computing system (HPCS) applications
403	2005	IC-1	A metric space for productivity measurement in software development
402	2005	EC-1	A Neuro-fuzzy based approach for the prediction of quality of reusable software components
401	2005	IC-1	A productivity metric based on statistical pattern recognition
400	2005	IC-1	A study on evaluation of component metric suites
399	2005	EC-1	A study on metrics for supporting the software process improvement based on SPICE
398	2005	EC-1	An empirical study of industrial requirements engineering process assessment and improvement
397	2005	EC-1	An investigation of cloning in web applications
396	2005	EC-1	An investigation of cloning in Web Applications
395	2005	IC-1	Application of a development time productivity metric to parallel software development
394	2005	IC-1	Enabling reuse-based software development of large-scale systems
393	2005	IC-1	Engineering-based processes and agile methodologies for software development: A comparative case study
392	2005	EC-1	Hybrid fuzzy metrics for software reusability
391	2005	EC-1	Increasing human-centred software development maturity in software development organizations
390	2005	EC-1	Measuring software processes performance based on fuzzy multi agent measurements
389	2005	EC-1	Measuring software processes performance based on the fuzzy multi-agent measurements
388	2005	EC-1	Performance rather than capability problems. Insights from assessments of usability engineering processes
387	2005	EC-1	Requirement process establishment and improvement: From the viewpoint of cybernetics
386	2005	IC-1	Software development productivity on a new platform: An industrial case study
385	2005	EC-1	Software project management using PROMPT: A hybrid metrics, modeling and utility framework
384	2005	EC-1	Software reuse research: Status and future

383	2005	EC-1	The added usefulness of process measures over performance measures in interface design
382	2005	EC-1	The impact of institutional forces on software metrics programs
381	2006	EC-1	A case-study of affect measurement tools for physical user interface design
380	2006	EC-1	A fuzzy-inference system based approach for the prediction of quality of reusable software components
379	2006	IC-1	Agent-based simulation of open source evolution
378	2006	IC-1	An empirical research of the software project measures model
377	2006	IC-1	Are CMM program investments beneficial? Analyzing past studies
376	2006	IC-1	Bayesian statistical effort prediction models for data-centred 4GL software development
375	2006	EC-1	BSR: A statistic-based approach for establishing and refining software process performance baseline
374	2006	EC-1	CMM implementation and organizational learning: Findings from a case study analysis
373	2006	IC-1	Comparison of software development life cycles: A multiproject experiment
372	2006	IC-1	Effectiveness of an integrated CASE tool for productivity and quality of software developments
371	2006	EC-1	Enhancing process management using software metrics: A case study
370	2006	IC-1	Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs
369	2006	EC-1	From compliance to business success: Improving outsourcing service controls by adopting external regulatory requirements
368	2006	IC-1	Further analysis on the evaluation of a size measure for Web applications
367	2006	EC-1	Increasing software engineering efficiency through defect tracking integration
366	2006	EC-1	Is 99% utilization of a supercomputer a good thing?
365	2006	EC-1	Managing non-invasive measurement tools
364	2006	IC-1	Motivations and measurements in an agile case study
363	2006	IC-1	Pair programming productivity: Novice-novice vs. expert-expert
362	2006	EC-1	Parallel performance wizard: A performance analysis tool for partitioned global-address-space programming models
361	2006	EC-1	Problems in measuring effectiveness in software process improvement: A longitudinal study of organizational change at Danske Data
360	2006	IC-1	Productivity of software projects: A case analysis
359	2006	EC-1	QoS analysis for component-based embedded software: Model and methodology
358	2006	EC-1	Quality of protection: Measuring the unmeasurable?
357	2006	EC-1	Requirement process establishment and improvement from the viewpoint of cybernetics
356	2006	EC-1	Software metrics for enhanced business excellence: An investigation of research issues from a macro perspective
355	2006	EC-1	SPDW: A software development process performance data warehousing environment
354	2006	EC-1	TCS Academic Interface Program (AIP) - A symbol of industry - Academia cooperation
353	2006	IC-1	The impact of software process maturity and software development risk on the performance of software development projects
352	2006	IC-1	Users and developers: An agent-based simulation of open source software evolution

351	2006	IC-1	Using data envelopment analysis in software development productivity measurement
350	2007	EC-1	A framework for the use of Six Sigma tools in PSP/TSP
349	2007	EC-1	An empirical study on establishing quantitative management model for testing process
348	2007	EC-1	An estimation model for test execution effort
347	2007	EC-1	An object-oriented framework for improving software reuse on automated testing of mobile phones
346	2007	EC-1	Cost-benefit analysis of software development techniques and practices
345	2007	EC-1	Debugging strategies and tactics in a multi-representation software environment
344	2007	EC-1	Design and development of software configuration management tool to support process performance monitoring and analysis
343	2007	EC-1	Designing an automated staff and organization performance appraisal system: A web-based approach
342	2007	EC-1	Do gradations of time zone separation make a difference in performance? A first laboratory study
341	2007	IC-1	Effect of team diversity on software project performance
340	2007	IC-1	Empirical study of the effects of open source adoption on software development economics
339	2007	EC-1	Enabling economics-driven systems engineering through reusable software architectures and components
338	2007	EC-1	Evaluation of students by measuring the complexity of their software product
337	2007	EC-1	Flexible measurement point management in an industrial automatic supervision system
336	2007	EC-1	How software process automation affects software evolution: A longitudinal empirical analysis
335	2007	IC-1	Impact of aspect-oriented programming on software development efficiency and design quality: An empirical study
334	2007	EC-1	Lean principles and techniques for improving the quality and productivity of software development projects: A case study
333	2007	IC-1	Managing software process measurement: A metamodel-based approach
332	2007	IC-1	Misleading metrics and unsound analyses
331	2007	EC-1	Modelling software processes as human-centered adaptive work systems
330	2007	EC-1	On supporting educational decision(s) for selectivity and/or development of software learning packages using artificial neural network modeling
329	2007	EC-1	Performance analysis of software processes supported by simulation: A resolution problem process case study
328	2007	EC-1	Performance measurement/analysis tool "mevalet"; performance measurement/analysis tool mevalet
327	2007	EC-1	Performance measures for supporting project manager decisions
326	2007	EC-1	Quality, productivity and economic benefits of software reuse: A review of industrial studies
325	2007	EC-1	Reusability evaluation with machine learning techniques
324	2007	EC-1	SEPT - Improving JSECST/ECSAMS in concert with the ATS framework
323	2007	IC-1	Sizing maintenance tasks for web applications
322	2007	IC-1	Software development risk and project performance measurement: Evidence in Korea
321	2007	IC-1	Summary of the 2006 model size metrics workshop

320	2007	EC-1	Targets, drivers and metrics in software process improvement: Results of a survey in a multinational organization
319	2007	IC-1	The impact of test-driven development on software development productivity - An empirical study
318	2007	EC-1	The knowledge based software process improvement program: A rational analysis
317	2007	EC-1	Towards adaptive project tracking using individual productivity metrics
316	2007	IC-1	Using stakeholder-driven process performance measurement for monitoring the performance of a Scrum-based software development process
315	2008	EC-1	A case study on SW product line architecture evaluation: Experience in the consumer electronics domain
314	2008	IC-1	A case study on the impact of refactoring on quality and productivity in an agile team
313	2008	IC-1	A coherent object-oriented (OO) software metric framework model: Software engineering
312	2008	EC-1	A method for stochastic modeling the software development process in constrained resource environments
311	2008	EC-1	A qualitative re-construction of project measurement criteria
310	2008	IC-1	An example of using key performance indicators for software development process efficiency evaluation
309	2008	IC-1	An investigation on performance of software enhancement projects in china
308	2008	EC-1	Challenges of scale: When all computing becomes grid computing
307	2008	EC-1	Combining regression and estimation by analogy in a semi-parametric model for software cost estimation
306	2008	IC-1	Cost effective software test metrics
305	2008	IC-1	Cross-company vs. single-company web effort models using the Tuketuku database: An extended study
304	2008	IC-1	Evaluating the performance of open source software projects using data envelopment analysis
303	2008	EC-1	Evaluating the reference and representation of domain concepts in APIs
302	2008	IC-1	Following the sun: Exploring productivity in temporally dispersed teams
301	2008	EC-1	Framework for quality metrics in mobile-wireless information systems
300	2008	IC-1	Framework for quantitative S/W development performance measurement and analysis in semiconductor industry
299	2008	EC-1	GENSIM 2.0: A customizable process simulation model for software process evaluation
298	2008	EC-1	How program history can improve code completion
297	2008	IC-1	How to use COSMIC functional size in effort estimation models?
296	2008	IC-1	Impact of programming and application-specific knowledge on maintenance effort: A hazard rate model
295	2008	EC-1	Integrating function point project information for improving the accuracy of effort estimation
294	2008	IC-1	Integrating functional metrics, COCOMO II and Earned Value Analysis for software projects using PMBoK
293	2008	EC-1	Measurement in software engineering: From the roadmap to the crossroads
292	2008	EC-1	Measures of farm business efficiency
291	2008	IC-1	Measuring function points from VDM-SL specifications
290	2008	IC-1	Mining individual performance indicators in collaborative development using software repositories
289	2008	EC-1	Need of appropriate component reusability metrics and standards for

			component-based systems
288	2008	EC-1	On the relation between class-count and modeling effort
287	2008	EC-1	Pacc starter kit: Developing software with predictable behavior
286	2008	EC-1	PADIC - Assessment and measurement based framework to improve productivity and predictability in engineering projects
285	2008	IC-1	PSPCAT: A PSP data collection and analysis tool
284	2008	EC-1	Quantifying functional reuse from object oriented requirements specifications
283	2008	EC-1	Quantitative process improvement in XP using six sigma tools
282	2008	EC-1	Quantitatively managing defects for iterative projects: An industrial experience report in China
281	2008	EC-1	Research on CMMI-based project management environment
280	2008	EC-1	Research on competitive powers evaluation of Chinese construction enterprises based on DEA
279	2008	IC-1	Software estimation tool based on three -layer model for software engineering metrics
278	2008	IC-1	Software productivity analysis with CSBSG data set
277	2008	EC-1	Software reusability model for procedure based domain-specific software components
276	2008	EC-1	Study of the relationship between the temporal variation of technology efficiency and its influencing factors in China's telecommunication industry
275	2008	EC-1	Teaching successful \"real-world\" software engineering to the \"Net\" Generation: Process and quality win!
274	2008	IC-1	Teaching team software process in graduate courses to increase productivity and improve software quality
273	2008	IC-1	Towards software process patterns: An empirical analysis of the behavior of student teams
272	2008	IC-1	Using the ProdFLOW approach to address the myth of productivity in R&D organizations
271	2008	IC-1	Using the TSPi defined process and improving the project management process
270	2009	EC-1	3rd workshop on assessment of contemporary modularization techniques (ACoM 2009)
269	2009	IC-1	A comparison of team performance measures for global software development student teams
268	2009	IC-1	A DEA evaluation of software project efficiency
267	2009	EC-1	A metric-based multi-agent system for software project management
266	2009	EC-1	A systematic literature review of software process improvement in small and medium web companies
265	2009	EC-1	An advanced platform to develop test software for domestic appliances based on hybrid architecture
264	2009	EC-1	An ontology-based approach for software measurement and suitability measurement repository evaluation to apply statistical software process control in high maturity organizations
263	2009	EC-1	Analyzing user behavior via gameplay metrics
262	2009	EC-1	Applicability of the capability maturity model for engineer-to-order firms
261	2009	IC-1	Are we more productive now? Analyzing change tasks to assess productivity trends during software evolution
260	2009	EC-1	Brain physiological characteristic analysis for software analysis support environments
259	2009	EC-1	DebugAdvisor: A recommender system for debugging

258	2009	EC-1	Designing a multi criteria evaluation model for project teams
257	2009	IC-1	Effect of staffing pattern on software project: An empirical analysis
256	2009	EC-1	Embedded software: Facts, figures, and future
255	2009	EC-1	Empirical investigations of model size, complexity and effort in a large scale, distributed model driven development process
254	2009	IC-1	Estimation of defect proneness using design complexity measurements in object-oriented software
253	2009	EC-1	Evaluating the impact of UML modeling on software quality: An industrial case study
252	2009	EC-1	Free-riding in student software development teams: An exploratory study
251	2009	EC-1	Impact of process improvement on software development predictions, for measuring software development project's performance benefits
250	2009	EC-1	Improvement opportunities and suggestions for benchmarking
249	2009	EC-1	Incentive systems in software organizations
248	2009	EC-1	Initial hybrid method for analyzing software estimation, benchmarking and risk assessment using design of software
247	2009	EC-1	Mapping approach for model transformation of MDA based on xUML
246	2009	IC-1	Measuring the effectiveness of nokia test in very small teams
245	2009	EC-1	Multi-criteria evaluation model for a software development project
244	2009	EC-1	Optimized resource allocation for software release planning
243	2009	EC-1	Quantitative defects management in iterative development with BiDefect
242	2009	IC-1	Requirements of software quality assurance model
241	2009	IC-1	Reward systems as a productivity improvement strategy in information technology environments
240	2009	EC-1	Software estimation: Universal models or multiple models?
239	2009	EC-1	Software productivity measurement: Past analysis and future trends
238	2009	EC-1	The Impact of Design and Code Reviews on Software Quality: An Empirical Study Based on PSP Data
237	2009	EC-1	The model of software process measurement and improvement driven by project performance
236	2009	EC-1	Tools and experiments supporting a testing-based theory of component composition
235	2009	EC-1	Towards effective productivity measurement in software projects
234	2009	EC-1	Towards gameplay analysis via gameplay metrics
233	2009	EC-1	Traditional and agile project management: A case study
232	2009	IC-1	Virtual organizational learning in open source software development projects
231	2010	EC-1	A COTS-based approach for estimating performance and energy consumption of embedded real-time systems
230	2010	EC-1	A method for evaluating the actual functional size in model driven software development
229	2010	IC-1	A method to measure productivity trends during software evolution
228	2010	EC-1	A socio-technical approach to improving the systems development process
227	2010	EC-1	A study of the uniqueness of source code
226	2010	EC-1	A well-founded software process behavior ontology to support business goals monitoring in high maturity software organizations

225	2010	EC-1	Applying SCRUM in an OSS development process: An empirical evaluation
224	2010	EC-1	Assessing the state of software in a large enterprise
223	2010	EC-1	Better defect detection and prevention through improved inspection and testing approach in small and medium scale software industry
222	2010	IC-1	Collaboration structure and performance in new software development: Findings from the study of open source projects
221	2010	EC-1	Consequences of business growth on software processes
220	2010	EC-1	Detecting duplicate bug report using character N-gram-based features
219	2010	IC-1	Developer fluency: Achieving true mastery in software projects
218	2010	EC-1	Discovering services during service-based system design using UML
217	2010	EC-1	Event-based metric for computing system complexity
216	2010	EC-1	Factors that influence the productivity of software developers in a developer view
215	2010	IC-1	Impact of programming language fragmentation on developer productivity: A sourceforge empirical study
214	2010	EC-1	Implementation of software process improvement through TSPi in very small enterprises
213	2010	EC-1	Improving end-user productivity in measurement systems with a domain-specific (modeling) language sequencer
212	2010	IC-1	IMPROVING OPEN SOURCE SOFTWARE MAINTENANCE
211	2010	EC-1	Integrating parallel application development with performance analysis in periscope
210	2010	EC-1	Managers' judgments of performance in IT services outsourcing
209	2010	EC-1	Measuring systems engineering productivity
208	2010	EC-1	On the importance of understanding the strategies that developers use
207	2010	EC-1	Operational definition and automated inference of test-driven development with Zorro
206	2010	EC-1	Page-based estimation methodology for software project
205	2010	EC-1	Penalty policies in professional software development practice: A multi-method field study
204	2010	EC-1	Predicting project health prior to inception
203	2010	EC-1	Queueing models based performance evaluation approach for video on demand back office system
202	2010	IC-1	Reuse metrics for object-oriented method
201	2010	EC-1	Risk assessment on distributed software projects
200	2010	IC-1	Shared visual attention in collaborative programming: A descriptive analysis
199	2010	IC-1	Software industry performance: What you measure is what you get
198	2010	IC-1	Software maintenance productivity and maturity
197	2010	EC-1	Software metrics for collaborative software engineering projects
196	2010	IC-1	The last mile: Parallel programming and usability
195	2010	IC-1	The Small-World Effect: The Influence of Macro-Level Properties of Developer Collaboration Networks on Open-Source Project Success
194	2010	EC-1	Towards predictive models of technology impact on software design productivity
193	2010	EC-1	Using a line-of-code Metric to understand software rework

192	2011	IC-1	A quantitative analysis into the economics of correcting software bugs
191	2011	IC-1	An analysis of trends in productivity and cost drivers over years
190	2011	EC-1	An approach for improving the social aspects of the software development process by using a game theoretic perspective: Towards a theory of social productivity of software development teams
189	2011	IC-1	An effective speedup metric for measuring productivity in large-scale parallel computer systems
188	2011	IC-1	An example of software metrics preparation
187	2011	IC-1	Analysis results on productivity variation in Force.com applications
186	2011	EC-1	Application of graphical programming and benefit of virtual instrumentation in teaching of state-of-the-art instrumentation
185	2011	IC-1	Assessing PSP effect in training disciplined software development: A Plan-Track-Review model
184	2011	IC-1	Assessment of software process and metrics to support quantitative understanding: Experience from an undefined task management process
183	2011	IC-1	Automatic mining of change set size information from repository for precise productivity estimation
182	2011	EC-1	Benchmarking embedded software development project performance
181	2011	EC-1	BioCreative III interactive task: An overview
180	2011	EC-1	Data analytics for game development (NIER track)
179	2011	EC-1	Defect management using depth of inspection and the inspection performance metric
178	2011	IC-1	Defining a catalog of indicators to support process performance analysis
177	2011	EC-1	Deployment of integrated design for the reduction of software complexity
176	2011	EC-1	Does adding manpower also affect quality? An empirical, longitudinal analysis
175	2011	EC-1	Exploring computer supported collaborative coordination through social networks
174	2011	EC-1	Graphical versus textual software measurement modelling: An empirical study
173	2011	EC-1	In-memory database support for source code search and analytics
172	2011	IC-1	Inferring skill from tests of programming performance: Combining time and quality
171	2011	EC-1	Investigating the effect of variations in the test development process: a case from a safety-critical system
170	2011	EC-1	Issues and strategy for agile global software development adoption
169	2011	EC-1	MANAGERS' PERCEPTIONS OF INFORMATION SYSTEM PROJECT SUCCESS
168	2011	EC-1	Measuring and predicting software productivity: A systematic map and review
167	2011	EC-1	Measuring the core competencies of service businesses: A resource-based view
166	2011	EC-1	Metrics center of excellence: From idea to implementation of a \"meaningful\" measurement and analysis process
165	2011	IC-1	New metric for measuring programmer productivity
164	2011	EC-1	Obtaining thresholds for the effectiveness of business process mining
163	2011	EC-1	On the broader view of the open source paradigm: The case for agricultural biotechnology
162	2011	EC-1	OPC historical data access - OPC foundation toolkit improvement suggestions



161	2011	EC-1	Predicting individual performance in student project teams
160	2011	IC-1	Productivity differences and catch-up effects among software as a service firms: A stochastic frontier approach
159	2011	EC-1	Quantitative analysis of the software change process applied for a large-scale banking application
158	2011	EC-1	R&D and catch-up effect among software-as-a-service firms: A stochastic frontier approach
157	2011	EC-1	Reduce fault density for top 3 requirement faults
156	2011	IC-1	Software estimation - A practitioner's perspective
155	2011	EC-1	Software process measurement based on six sigma
154	2011	EC-1	State of software metrics to forecast variety of elements in the software development process
153	2011	EC-1	Statistical prediction modeling for software development process performance
152	2011	EC-1	The construction of educational software development platform based on Flash
151	2011	EC-1	The design of software process management and evaluation system in small and medium software enterprises
150	2011	EC-1	The evaluation to regional development efficiency of software industry in China
149	2011	EC-1	Understanding need of flexible software development approach using \"The Economic Model\"; understanding need of flexible software development approach using the economic model
148	2011	EC-1	US DoD application domain empirical software cost analysis
147	2011	IC-1	Using software evolution history to facilitate development and maintenance
146	2011	EC-1	Using the Affect Grid to Measure Emotions in Software Requirements Engineering
145	2011	EC-1	UWA Java tools: Harnessing software metrics to support novice programmers
144	2011	IC-1	Why you must change to cosmic for sizing and estimation
143	2012	EC-1	A methodology to reconfigure victim components using modularity
142	2012	EC-1	An experimental study of a design-driven, tool-based development approach
141	2012	IC-1	Analysis of cultural and gender influences on teamwork performance for software requirements analysis in multinational environments
140	2012	EC-1	Application of the methods of complexation of analogs and fuzzy logic for prediction of some operation metrics
139	2012	EC-1	Application S/W re-engineering approach in the steel plant to improve productivity efficiently
138	2012	EC-1	Apply quantitative management now
137	2012	EC-1	Applying industrial-strength testing techniques to critical care medical equipment
136	2012	EC-1	Comparison of checking behavior in adults with or without checking symptom of obsessive-compulsive disorder using a novel computer-based measure
135	2012	EC-1	Comparison of seven bug report types: A case-study of Google chrome browser project
134	2012	EC-1	DAG3: A tool for design and analysis of applications for multicore architectures
133	2012	EC-1	Design science approach to measure productivity in agile software development
132	2012	EC-1	Development and application of a simulation environment (NEO) for integrating empirical and computational investigations of system-level

			complexity
131	2012	EC-1	Dispersion, coordination and performance in global software teams: A systematic review
130	2012	EC-1	DroidSense: A mobile tool to analyze software development processes by measuring team proximity
129	2012	EC-1	Empirical analysis of user data in game software development: The story of project gotham racing 4
128	2012	EC-1	Employee perception towards electronic monitoring at work place and its impact on job satisfaction of software professionals in Sri Lanka
127	2012	EC-1	Estimating packaged software implementations: The first part of a framework
126	2012	IC-1	Estimating productivity of software development using the total factor productivity approach
125	2012	IC-1	Evaluation of issue-tracker's effectiveness for measuring individual performance on group projects
124	2012	IC-1	Experimental investigation of the quality and productivity of software factories based development
123	2012	EC-1	Functional size measurement of electronic control units software designed following the AUTOSAR standard: A measurement guideline based on the COSMIC ISO 19761 standard
122	2012	EC-1	Graph-based analysis and prediction for software evolution
121	2012	IC-1	Impact of CMMI-based process maturity levels on effort, productivity and diseconomy of scale
120	2012	EC-1	Increasing quality and managing complexity in neuroinformatics software development with continuous integration
119	2012	IC-1	Integrating GQM and data warehousing for the definition of software reuse metrics
118	2012	IC-1	Investigating object-oriented design metrics to predict fault-proneness of software modules
117	2012	EC-1	Is software "green"? Application development environments and energy efficiency in open source applications
116	2012	EC-1	Measuring and predicting software economics and productivity: A road map to future
115	2012	EC-1	Measuring the efficiency of rural informatization in China 2007-2009: An application of data envelopment analysis
114	2012	EC-1	Measuring UML model similarity
113	2012	EC-1	Metrics based software supplier selection - Best practice used in the largest Dutch telecom company
112	2012	EC-1	Position precise control system of ball head pin Riveting Machine's axis
111	2012	IC-1	Process performance: Words of wisdom
110	2012	EC-1	Product metrics for IEC 61131-3 languages
109	2012	EC-1	Professional status and expertise for UML class diagram comprehension: An empirical study
108	2012	EC-1	PSP PAIR: Automated personal software process performance analysis and improvement recommendation
107	2012	EC-1	Quality enhancement by implementation of depth of inspection metric and inspection performance metric in software industry
106	2012	IC-1	Quantifying the effect of using Kanban versus scrum: A case study
105	2012	EC-1	Recalling the "imprecision" of cross-project defect prediction
104	2012	EC-1	Recommender systems for manual testing: Deciding how to assign tests in a test team
103	2012	EC-1	Refactoring meets spreadsheet formulas

102	2012	EC-1	Satisfaction and motivation: IT practitioners' perspective
101	2012	IC-1	Significance of depth of inspection and inspection performance metrics for consistent defect management in software industry
100	2012	IC-1	Social capital as a determinant factor of software development productivity: An empirical study using structural equation modeling
99	2012	EC-1	Social media and success in open source projects
98	2012	EC-1	Software performance monitoring using aggregated performance metrics by Z-value
97	2012	IC-1	Software productivity: Harmonization in ISO/IEEE software engineering standards
96	2012	EC-1	Structural complexity and programmer team strategy: An experimental test
95	2012	EC-1	Support for Statistic Process Control of software process
94	2012	EC-1	The development and achievements of software size measurement
93	2012	EC-1	Tool for calculating reusability of object oriented programs
92	2012	EC-1	Towards an ontology-based retrieval of UML class diagrams
91	2012	EC-1	UMAM-Q: An instrument to assess the intention to use software development methodologies
90	2012	EC-1	Using CHARTER tools to develop a safety-critical avionics application in java
89	2012	IC-1	Using test cases to size systems: A case study
88	2013	IC-1	A distinctive suite of performance metrics for software design
87	2013	IC-1	A lean approach to estimate the functional size of operating applications
86	2013	EC-1	A pilot study: Opportunities for improving software quality via application of CMMI measurement and analysis
85	2013	IC-1	A software quality predictive model
84	2013	IC-1	A SYSTEMATIC MAPPING STUDY OF EMPIRICAL STUDIES ON THE USE OF PAIR PROGRAMMING IN INDUSTRY
83	2013	IC-1	Achieving maturity (and measuring performance) through model-based process improvement
82	2013	EC-1	An empirical evaluation of refactoring crosscutting concerns into aspects using software metrics
81	2013	IC-1	Are happy developers more productive? The correlation of affective states of software developers and their self-assessed productivity
80	2013	IC-1	Assessing individual performance in Agile undergraduate software engineering teams
79	2013	EC-1	Characterizing and profiling scientific workflows
78	2013	IC-1	Coordination breakdowns and their impact on development productivity and software failures
77	2013	EC-1	Correlation between the habitats productivity and species richness (amphibians and reptiles) in Portugal, through remote sensed data
76	2013	EC-1	Cycle time reduction in context to the make to order (MTO) environment
75	2013	EC-1	Development of a novel semantic-based system integration framework
74	2013	EC-1	Evaluation of students' modeling and programming skills
73	2013	EC-1	Games in the workplace: Revolutionary or run-of-the-mill?
72	2013	IC-1	How commercial involvement affects open source projects: Three case studies on issue reporting
71	2013	EC-1	How Does Software Visualization Contribute to Software Comprehension? A Grounded Theory Approach

70	2013	EC-1	Impact of refactoring on external code quality improvement: An empirical evaluation
69	2013	EC-1	Measuring best-in-class software releases
68	2013	EC-1	Modeling user story completion of an agile software process
67	2013	EC-1	On the development of a theoretical model of the impact of trust in the performance of distributed software projects
66	2013	EC-1	Opincaa: A light-weight and flexible programming environment for parallel simd accelerators
65	2013	EC-1	Peer assessment in experiential learning: Assessing tacit and explicit skills in agile software engineering capstone projects
64	2013	EC-1	Performance measurement of Web applications using automated tools
63	2013	IC-1	Quantitative analysis on performance of software projects
62	2013	EC-1	Rationalization of business software systems development and enhancement projects investment decisions on the basis of functional size measurement
61	2013	EC-1	Samekana: A Browser Extension for including relevant web links in issue tracking system discussion forum
60	2013	IC-1	Software engineering job productivity-a systematic review
59	2013	EC-1	Testing-effort dependent software reliability model for distributed systems
58	2013	IC-1	Towards a metric suite proposal to quantify confirmation biases of developers
57	2013	EC-1	Towards precise metrics for predicting graph query performance
56	2014	IC-1	A complete and comprehensive metrics suite for object-oriented design quality assessment
55	2014	IC-1	A model for analyzing estimation, productivity, and quality performance in the personal software process
54	2014	IC-1	An empirical study of software reuse and quality in an industrial setting
53	2014	EC-1	An exploratory study on websites quality assessment
52	2014	EC-1	An object based software tool for software measurement
51	2014	IC-1	Applying model-driven engineering in small software enterprises
50	2014	EC-1	Automated productivity assessment of earthmoving operations
49	2014	EC-1	Coevolution of variability models and code: An industrial case study
48	2014	IC-1	Construction and validation of an instrument for measuring programming skill
47	2014	IC-1	Critical analysis of object oriented metrics in software development
46	2014	EC-1	Dynamic program analysis - Reconciling developer productivity and tool performance
45	2014	IC-1	Dynamic program analysis-Reconciling developer productivity and tool performance
44	2014	EC-1	Effective approach to quality control for small-medium software companies
43	2014	EC-1	Evaluating scenario-based SPL requirements approaches: the case for modularity, stability and expressiveness
42	2014	EC-1	Evaluating software merge quality
41	2014	IC-1	Evaluating the productivity of a reference-based programming approach: A controlled experiment
40	2014	IC-1	Factors affecting team performance in globally distributed setting
39	2014	IC-1	Function point structure and applicability validation using the ISBSG dataset: A replicated study

38	2014	EC-1	Functional size estimation technologies for software maintenance
37	2014	EC-1	Hand-held computers to increase accuracy and productivity in agricultural work study
36	2014	IC-1	Impact of test effort in software development life cycle for effective defect management
35	2014	EC-1	IntroPerf: Transparent context-sensitive multi-layer performance inference using system stack traces
34	2014	EC-1	Investigating the skill gap between graduating students and industry expectations
33	2014	IC-1	Manage the automotive embedded software development cost & productivity with the automation of a functional size measurement method (COSMIC)
32	2014	EC-1	Managing distributed software development with performance measures
31	2014	IC-1	Measuring the software size of sliced v-model projects
30	2014	IC-1	Process mining multiple repositories for software defect resolution from control and organizational perspective
29	2014	IC-1	Productivity monitoring process using FPA - Improving your development process using productivity indicators
28	2014	EC-1	Requirements engineering quality revealed through functional size measurement: An empirical study in an agile context
27	2014	EC-1	Sirius: A rapid development of DSM graphical editor
26	2014	IC-1	Software domains in incremental development productivity decline
25	2014	EC-1	Software estimation: Transforming dust into pots of gold?
24	2014	IC-1	Software process evaluation: a machine learning framework with application to defect management process
23	2014	EC-1	Software project management: Towards failure avoidance
22	2014	IC-1	Systematic analyses and comparison of development performance and product quality of Incremental Process and Agile Process
21	2014	IC-1	The added value of enhancement function points - An empirical evaluation
20	2014	EC-1	Towards standardization of measuring the usability of parallel languages
19	2014	IC-1	User liaisons' perspective on behavior and outcome control in IT projects Role of IT experience, behavior observability, and outcome measurability
18	2014	IC-1	Version control system gamification: A proposal to encourage the engagement of developers to collaborate in software projects
17	2015	IC-1	A multi-lingual management process for software interface consistency
16	2015	EC-1	A proposal for the improvement of project's cost predictability using earned value management and historical data of cost - An empirical study
15	2015	IC-1	An empirical research agenda for understanding formal methods productivity
14	2015	EC-1	An empirical validation of function point structure and applicability: A replication study
13	2015	IC-1	An evaluation of functional size measurement methods
12	2015	IC-1	An innovative measurement programme for agile governance
11	2015	IC-1	Benchmarking software development productivity of CMMI level 5 projects
10	2015	IC-1	Do feelings matter? On the correlation of affects and the self-assessed productivity in software engineering
9	2015	EC-1	Do PageRank-based author rankings outperform simple citation counts?
8	2015	IC-1	Effects of cohesion-based feedback on the collaborations in global software development teams

7	2015	IC-1	Lapis - logo agile process improvement system
6	2015	IC-1	Mobile platform products supporting use of smart devices
5	2015	IC-1	Productivity measurement in software engineering: A study of the inputs and the outputs
4	2015	IC-1	Quantifying fair payment after outsourcing - A case study
3	2015	EC-1	Real time power consumption monitoring for energy efficiency analysis in micro EDM milling
2	2015	IC-1	Task mental model and software developers' performance: An experimental investigation
1	2015	EC-1	The role of innovation in inventory turnover performance

## 2. Results from the second filter

<b>Id</b>	<b>Year</b>	<b>Criterion</b>	<b>Publication</b>
625	1979	EC-1	Measuring the Psychological Complexity of Software Maintenance Tasks with the Halstead and McCabe Metrics
623	1981	IC-1	Programming measurement and estimation in the software engineering laboratory
619	1987	EC-5	COMMENTS, WITH AUTHOR'S REPLY, ON 'IMPROVING SOFTWARE PRODUCTIVITY' BY B. W. BOEHM.
618	1987	IC-1	EVALUATING SOFTWARE ENGINEERING TECHNOLOGIES.
617	1988	IC-1	SOFTWARE DEVELOPMENT PRODUCTIVITY TOOLS AND METRICS.
615	1989	EC-3	A summary of software measurement experiences in the Software Engineering Laboratory
611	1989	EC-1	Software development: state of the art vs. state of the practice
607	1990	EC-1	A study of the impact of C++ on software maintenance
597	1991	IC-1	Cyclomatic complexity density and software maintenance productivity
596	1991	EC-1	Model to evaluate variables impacting the productivity of software maintenance projects
595	1991	IC-1	Predicting (individual) software productivity
594	1991	IC-1	Reuse and productivity in integrated computer-aided software engineering: An empirical study
593	1992	EC-5	CUSTOMIZED SYSTEMS FOR ENGINEERING APPLICATIONS
592	1992	EC-3	Information models of software productivity: Limits on productivity growth
591	1992	EC-2	Productivity analysis of software development with an integrated CASE tool
590	1992	EC-3	Software productivity metrics: who needs them?
587	1993	IC-1	CP-6: quality and productivity measures in the 15-year life cycle of an operating system
586	1993	IC-1	Exploration of the impact of individual and group factors on programmer productivity
582	1993	IC-1	On the study of software reuse using reusable C++ components
579	1993	IC-1	Software process maturity: measuring its impact on productivity and quality
575	1994	IC-1	CASE-STUDIES OF SOFTWARE-PROCESS-IMPROVEMENT MEASUREMENT
574	1994	IC-1	Effects of Reuse on Quality, Productivity, and Economics

570	1994	IC-1	Perceptions of the benefits from the introduction of CASE: An empirical study
567	1994	EC-3	Using Metrics to Manage Software Projects
566	1995	IC-1	Analysis of review's effectiveness based on software metrics
565	1995	IC-1	Analytical and empirical evaluation of software reuse metrics
564	1995	EC-1	Approaches to making software porting more productive
563	1995	IC-1	CHANGE-POINTS: A proposal for software productivity measurement
559	1995	EC-5	Method for measuring programmer debugging performance from key strokes
557	1995	EC-1	Neural fuzzy system to evaluate software development productivity
556	1995	EC-3	Personal 'progress functions' in the software process
553	1995	EC-3	Sizing measure for adaptive maintenance work products
547	1996	IC-1	Function point sizing: Structure, validity and applicability
545	1996	EC-5	Measuring productivity of software projects: A data envelopment analysis approach
543	1996	EC-1	Programmers' performance on structured versus nonstructured function definitions
542	1996	IC-1	Software development productivity of european space, military, and industrial applications
541	1996	IC-1	The effect of object-oriented frameworks on developer productivity
536	1997	EC-1	An empirical study of software reuse with special attention to Ada
534	1997	EC-1	Effect of software structure attributes on software development productivity
533	1997	IC-1	Estimating software development effort with connectionist models
531	1997	EC-1	Experiences introducing a measurement program
530	1997	EC-5	Function points and their use
529	1997	EC-5	Function points and their use
524	1997	EC-3	Measuring the performance of a software maintenance department
516	1998	IC-1	Analyzing effects of cost estimation accuracy on quality and productivity
511	1998	IC-1	Managerial use of metrics for object-oriented software: An exploratory analysis
509	1998	IC-1	Measuring the impacts individual process maturity attributes have on software products
507	1998	EC-1	Software development practices, software complexity, and software maintenance performance: A field study
506	1998	EC-3	Software size measurement and productivity rating in a large-scale software development department
502	1999	IC-1	A performance measure for software reuse projects
496	1999	IC-1	Comparing observed bug and productivity rates for Java and C++
494	1999	EC-1	Empirical evaluation of reuse sensitiveness of complexity metrics
493	1999	IC-1	Framework based software development: Investigating the learning effect
491	1999	IC-1	Measuring functionality and productivity in Web-based applications: A case study
489	1999	EC-5	Neural networks for software metrics estimation

487	1999	EC-4	REMEX - A case-based approach for reusing software measurement experienceware
482	2000	EC-3	Algorithmic cost estimation for software evolution
481	2000	IC-1	Benchmarking software development productivity
478	2000	IC-1	Case study of open source software development: the Apache server
477	2000	IC-1	How does radical collocation help a team succeed?
474	2000	EC-1	Metrics in the development and maintenance of software: An application in a large scale environment
470	2000	IC-1	Software engineering productivity measurement using function points: A case study
465	2000	EC-2	Validating the ISO/IEC 15504 measures of software development process capability
462	2001	IC-1	An empirical study of software productivity
459	2001	EC-1	Assessing massive maintenance processes: An empirical study
452	2002	EC-1	Disaggregating and calibrating the CASE tool variable in COCOMO II
451	2002	EC-1	Empirical analysis of massive maintenance processes
444	2002	IC-1	Two case studies of open source software development: Apache and Mozilla
436	2003	EC-1	Empirical analysis of CK metrics for object-oriented design complexity: Implications for software defects
435	2003	IC-1	Identifying high performance ERP projects
432	2003	EC-1	Simple metrics for improving software process performance and capability: A case study
431	2003	IC-1	Towards meaningful benchmarking of software development team productivity
428	2004	IC-1	A field study of developer pairs: Productivity impacts and implications
423	2004	EC-1	An exploration of the relationship between software development process maturity and project performance
422	2004	EC-1	An extension of SEMEST: The online software engineering measurement tool
421	2004	IC-1	Are individual differences in software development performance possible to capture using a quantitative survey?
419	2004	IC-1	DEA evaluation of a Y2K software retrofit program
418	2004	EC-3	Defining and measuring the productivity of programming languages
413	2004	EC-3	Jackson networks and Markov processes for resource allocation modeling
407	2004	IC-1	Software productivity measurement using multiple size measures
403	2005	EC-1	A metric space for productivity measurement in software development
401	2005	IC-1	A productivity metric based on statistical pattern recognition
400	2005	EC-1	A study on evaluation of component metric suites
395	2005	EC-2	Application of a development time productivity metric to parallel software development
394	2005	IC-1	Enabling reuse-based software development of large-scale systems
393	2005	EC-1	Engineering-based processes and agile methodologies for software development: A comparative case study
386	2005	EC-1	Software development productivity on a new platform: An industrial case study
379	2006	EC-3	Agent-based simulation of open source evolution



378	2006	EC-5	An empirical research of the software project measures model
377	2006	IC-1	Are CMM program investments beneficial? Analyzing past studies
376	2006	EC-1	Bayesian statistical effort prediction models for data-centred 4GL software development
373	2006	IC-1	Comparison of software development life cycles: A multiproject experiment
372	2006	EC-2	Effectiveness of an integrated CASE tool for productivity and quality of software developments
370	2006	EC-1	Faster, better, cheaper: A study of NPD project efficiency and performance tradeoffs
368	2006	IC-1	Further analysis on the evaluation of a size measure for Web applications
364	2006	EC-3	Motivations and measurements in an agile case study
363	2006	IC-1	Pair programming productivity: Novice-novice vs. expert-expert
360	2006	EC-5	Productivity of software projects: A case analysis
353	2006	EC-1	The impact of software process maturity and software development risk on the performance of software development projects
352	2006	EC-4	Users and developers: An agent-based simulation of open source software evolution
351	2006	EC-1	Using data envelopment analysis in software development productivity measurement
341	2007	EC-1	Effect of team diversity on software project performance
340	2007	EC-1	Empirical study of the effects of open source adoption on software development economics
335	2007	IC-1	Impact of aspect-oriented programming on software development efficiency and design quality: An empirical study
333	2007	EC-1	Managing software process measurement: A metamodel-based approach
332	2007	IC-1	Misleading metrics and unsound analyses
323	2007	EC-1	Sizing maintenance tasks for web applications
322	2007	EC-1	Software development risk and project performance measurement: Evidence in Korea
321	2007	EC-1	Summary of the 2006 model size metrics workshop
319	2007	EC-4	The impact of test-driven development on software development productivity - An empirical study
316	2007	EC-1	Using stakeholder-driven process performance measurement for monitoring the performance of a Scrum-based software development process
314	2008	IC-1	A case study on the impact of refactoring on quality and productivity in an agile team
313	2008	EC-1	A coherent object-oriented (OO) software metric framework model: Software engineering
310	2008	EC-1	An example of using key performance indicators for software development process efficiency evaluation
309	2008	IC-1	An investigation on performance of software enhancement projects in china
306	2008	EC-1	Cost effective software test metrics
305	2008	IC-1	Cross-company vs. single-company web effort models using the Tukutuku database: An extended study
304	2008	IC-1	Evaluating the performance of open source software projects using data envelopment analysis
302	2008	IC-1	Following the sun: Exploring productivity in temporally dispersed teams
300	2008	EC-1	Framework for quantitative S/W development performance measurement and analysis in semiconductor industry

297	2008	EC-4	How to use COSMIC functional size in effort estimation models?
296	2008	EC-1	Impact of programming and application-specific knowledge on maintenance effort: A hazard rate model
294	2008	EC-1	Integrating functional metrics, COCOMO II and Earned Value Analysis for software projects using PMBoK
291	2008	EC-1	Measuring function points from VDM-SL specifications
290	2008	EC-1	Mining individual performance indicators in collaborative development using software repositories
285	2008	EC-5	PSPCAT: A PSP data collection and analysis tool
279	2008	EC-3	Software estimation tool based on three -layer model for software engineering metrics
278	2008	IC-1	Software productivity analysis with CSBSG data set
274	2008	IC-1	Teaching team software process in graduate courses to increase productivity and improve software quality
273	2008	EC-1	Towards software process patterns: An empirical analysis of the behavior of student teams
272	2008	EC-3	Using the ProdFLOW approach to address the myth of productivity in R&D organizations
271	2008	IC-1	Using the TSPi defined process and improving the project management process
269	2009	EC-1	A comparison of team performance measures for global software development student teams
268	2009	IC-1	A DEA evaluation of software project efficiency
261	2009	EC-1	Are we more productive now? Analyzing change tasks to assess productivity trends during software evolution
257	2009	IC-1	Effect of staffing pattern on software project: An empirical analysis
254	2009	EC-1	Estimation of defect proneness using design complexity measurements in object-oriented software
246	2009	EC-5	Measuring the effectiveness of nokia test in very small teams
242	2009	EC-3	Requirements of software quality assurance model
241	2009	EC-5	Reward systems as a productivity improvement strategy in information technology environments
232	2009	EC-1	Virtual organizational learning in open source software development projects
229	2010	EC-4	A method to measure productivity trends during software evolution
222	2010	IC-1	Collaboration structure and performance in new software development: Findings from the study of open source projects
219	2010	IC-1	Developer fluency: Achieving true mastery in software projects
215	2010	IC-1	Impact of programming language fragmentation on developer productivity: A sourceforge empirical study
212	2010	EC-5	IMPROVING OPEN SOURCE SOFTWARE MAINTENANCE
202	2010	EC-1	Reuse metrics for object-oriented method
200	2010	EC-1	Shared visual attention in collaborative programming: A descriptive analysis
199	2010	EC-3	Software industry performance: What you measure is what you get
198	2010	IC-1	Software maintenance productivity and maturity
196	2010	EC-1	The last mile: Parallel programming and usability
195	2010	EC-1	The Small-World Effect: The Influence of Macro-Level Properties of Developer Collaboration Networks on Open-Source Project Success

192	2011	EC-4	A quantitative analysis into the economics of correcting software bugs
191	2011	IC-1	An analysis of trends in productivity and cost drivers over years
189	2011	EC-2	An effective speedup metric for measuring productivity in large-scale parallel computer systems
188	2011	EC-1	An example of software metrics preparation
187	2011	IC-1	Analysis results on productivity variation in Force.com applications
185	2011	IC-1	Assessing PSP effect in training disciplined software development: A Plan-Track-Review model
184	2011	EC-4	Assessment of software process and metrics to support quantitative understanding: Experience from an undefined task management process
183	2011	IC-1	Automatic mining of change set size information from repository for precise productivity estimation
178	2011	EC-3	Defining a catalog of indicators to support process performance analysis
172	2011	EC-1	Inferring skill from tests of programming performance: Combining time and quality
165	2011	EC-3	New metric for measuring programmer productivity
160	2011	EC-5	Productivity differences and catch-up effects among software as a service firms: A stochastic frontier approach
156	2011	EC-5	Software estimation - A practitioner's perspective
147	2011	EC-1	Using software evolution history to facilitate development and maintenance
144	2011	EC-1	Why you must change to cosmic for sizing and estimation
141	2012	EC-1	Analysis of cultural and gender influences on teamwork performance for software requirements analysis in multinational environments
126	2012	EC-3	Estimating productivity of software development using the total factor productivity approach
125	2012	EC-1	Evaluation of issue-tracker's effectiveness for measuring individual performance on group projects
124	2012	EC-1	Experimental investigation of the quality and productivity of software factories based development
121	2012	IC-1	Impact of CMMI-based process maturity levels on effort, productivity and diseconomy of scale
119	2012	EC-3	Integrating GQM and data warehousing for the definition of software reuse metrics
118	2012	EC-1	Investigating object-oriented design metrics to predict fault-proneness of software modules
111	2012	EC-1	Process performance: Words of wisdom
106	2012	IC-1	Quantifying the effect of using Kanban versus scrum: A case study
101	2012	EC-1	Significance of depth of inspection and inspection performance metrics for consistent defect management in software industry
100	2012	EC-1	Social capital as a determinant factor of software development productivity: An empirical study using structural equation modeling
97	2012	EC-3	Software productivity: Harmonization in ISO/IEEE software engineering standards
89	2012	EC-1	Using test cases to size systems: A case study
88	2013	EC-3	A distinctive suite of performance metrics for software design
87	2013	EC-1	A lean approach to estimate the functional size of operating applications
85	2013	EC-1	A software quality predictive model
84	2013	EC-1	A SYSTEMATIC MAPPING STUDY OF EMPIRICAL STUDIES ON THE USE OF PAIR PROGRAMMING IN INDUSTRY

83	2013	EC-1	Achieving maturity (and measuring performance) through model-based process improvement
81	2013	EC-4	Are happy developers more productive? The correlation of affective states of software developers and their self-assessed productivity
80	2013	EC-1	Assessing individual performance in Agile undergraduate software engineering teams
78	2013	EC-1	Coordination breakdowns and their impact on development productivity and software failures
72	2013	EC-1	How commercial involvement affects open source projects: Three case studies on issue reporting
63	2013	EC-5	Quantitative analysis on performance of software projects
60	2013	EC-3	Software engineering job productivity-a systematic review
58	2013	EC-1	Towards a metric suite proposal to quantify confirmation biases of developers
56	2014	EC-1	A complete and comprehensive metrics suite for object-oriented design quality assessment
55	2014	EC-3	A model for analyzing estimation, productivity, and quality performance in the personal software process
54	2014	IC-1	An empirical study of software reuse and quality in an industrial setting
51	2014	EC-1	Applying model-driven engineering in small software enterprises
48	2014	EC-1	Construction and validation of an instrument for measuring programming skill
47	2014	EC-1	Critical analysis of object oriented metrics in software development
45	2014	EC-1	Dynamic program analysis-Reconciling developer productivity and tool performance
41	2014	EC-1	Evaluating the productivity of a reference-based programming approach: A controlled experiment
40	2014	EC-1	Factors affecting team performance in globally distributed setting
39	2014	EC-1	Function point structure and applicability validation using the ISBSG dataset: A replicated study
36	2014	EC-5	Impact of test effort in software development life cycle for effective defect management
33	2014	EC-1	Manage the automotive embedded software development cost & productivity with the automation of a functional size measurement method (COSMIC)
31	2014	EC-1	Measuring the software size of sliced v-model projects
30	2014	EC-1	Process mining multiple repositories for software defect resolution from control and organizational perspective
29	2014	EC-1	Productivity monitoring process using FPA - Improving your development process using productivity indicators
26	2014	IC-1	Software domains in incremental development productivity decline
22	2014	IC-1	Systematic analyses and comparison of development performance and product quality of Incremental Process and Agile Process
21	2014	IC-1	The added value of enhancement function points - An empirical evaluation
19	2014	EC-1	User liaisons' perspective on behavior and outcome control in IT projects Role of IT experience, behavior observability, and outcome measurability
18	2014	EC-4	Version control system gamification: A proposal to encourage the engagement of developers to collaborate in software projects
17	2015	EC-5	A multi-lingual management process for software interface consistency
15	2015	EC-3	An empirical research agenda for understanding formal methods productivity
13	2015	EC-1	An evaluation of functional size measurement methods

12	2015	EC-1	An innovative measurement programme for agile governance
11	2015	IC-1	Benchmarking software development productivity of CMMI level 5 projects
10	2015	EC-1	Do feelings matter? On the correlation of affects and the self-assessed productivity in software engineering
8	2015	EC-1	Effects of cohesion-based feedback on the collaborations in global software development teams
7	2015	EC-4	Lapis - logo agile process improvement system
6	2015	EC-1	Mobile platform products supporting use of smart devices
5	2015	EC-3	Productivity measurement in software engineering: A study of the inputs and the outputs
4	2015	EC-3	Quantifying fair payment after outsourcing - A case study
2	2015	EC-1	Task mental model and software developers' performance: An experimental investigation

### 3. Final Result

<b>Id</b>	<b>Year</b>	<b>Criterion</b>	<b>Publication</b>
623	1981	CI.1	Programming measurement and estimation in the software engineering laboratory
618	1987	CI.1	EVALUATING SOFTWARE ENGINEERING TECHNOLOGIES.
617	1988	CI.1	SOFTWARE DEVELOPMENT PRODUCTIVITY TOOLS AND METRICS.
597	1991	CI.1	Cyclomatic complexity density and software maintenance productivity
595	1991	CI.1	Predicting (individual) software productivity
594	1991	CI.1	Reuse and productivity in integrated computer-aided software engineering: An empirical study
587	1993	CI.1	CP-6: quality and productivity measures in the 15-year life cycle of an operating system
586	1993	CI.1	Exploration of the impact of individual and group factors on programmer productivity
582	1993	CI.1	On the study of software reuse using reusable C++ components
579	1993	CI.1	Software process maturity: measuring its impact on productivity and quality
575	1994	CI.1	CASE-STUDIES OF SOFTWARE-PROCESS-IMPROVEMENT MEASUREMENT
574	1994	CI.1	Effects of Reuse on Quality, Productivity, and Economics
570	1994	CI.1	Perceptions of the benefits from the introduction of CASE: An empirical study
566	1995	CI.1	Analysis of review's effectiveness based on software metrics
565	1995	CI.1	Analytical and empirical evaluation of software reuse metrics
564	1995	CE.1	Approaches to making software porting more productive
563	1995	CI.1	CHANGE-POINTS: A proposal for software productivity measurement
547	1996	CI.1	Function point sizing: Structure, validity and applicability
542	1996	CI.1	Software development productivity of european space, military, and industrial applications
541	1996	CI.1	The effect of object-oriented frameworks on developer productivity

533	1997	CI.1	Estimating software development effort with connectionist models
516	1998	CI.1	Analyzing effects of cost estimation accuracy on quality and productivity
511	1998	CI.1	Managerial use of metrics for object-oriented software: An exploratory analysis
509	1998	CI.1	Measuring the impacts individual process maturity attributes have on software products
502	1999	CI.1	A performance measure for software reuse projects
496	1999	CI.1	Comparing observed bug and productivity rates for Java and C++
493	1999	CI.1	Framework based software development: Investigating the learning effect
491	1999	CI.1	Measuring functionality and productivity in Web-based applications: A case study
481	2000	CI.1	Benchmarking software development productivity
478	2000	CI.1	Case study of open source software development: the Apache server
477	2000	CI.1	How does radical collocation help a team succeed?
470	2000	CI.1	Software engineering productivity measurement using function points: A case study
462	2001	CI.1	An empirical study of software productivity
444	2002	CI.1	Two case studies of open source software development: Apache and Mozilla
435	2003	CI.1	Identifying high performance ERP projects
431	2003	CI.1	Towards meaningful benchmarking of software development team productivity
428	2004	CI.1	A field study of developer pairs: Productivity impacts and implications
421	2004	CI.1	Are individual differences in software development performance possible to capture using a quantitative survey?
419	2004	CI.1	DEA evaluation of a Y2K software retrofit program
407	2004	CI.1	Software productivity measurement using multiple size measures
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363	2006	CI.1	Pair programming productivity: Novice-novice vs. expert-expert
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332	2007	CI.1	Misleading metrics and unsound analyses
314	2008	CI.1	A case study on the impact of refactoring on quality and productivity in an agile team
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305	2008	CI.1	Cross-company vs. single-company web effort models using the Tukutuku database: An extended study
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274	2008	CI.1	Teaching team software process in graduate courses to increase productivity and improve software quality
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106	2012	CI.1	Quantifying the effect of using Kanban versus scrum: A case study
54	2014	CI.1	An empirical study of software reuse and quality in an industrial setting
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22	2014	CI.1	Systematic analyses and comparison of development performance and product quality of Incremental Process and Agile Process
21	2014	CI.1	The added value of enhancement function points - An empirical evaluation
11	2015	CI.1	Benchmarking software development productivity of CMMI level 5 projects

#### 4. Reference

Oliveira, E., Viana, D., Cristo, M. e Conte, T. (2016). TR-USES-2016-007. “*A Systematic Mapping on Productivity Metrics in Software Development and Maintenance*”. USES Technical Report. *In Portuguese*.