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Papers: Systematic Review on the Use of Metrics for Estimating the Effort and Cost of Software Applicable to the Brazilian Public Sector



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Purpose of Paper

Identify metrics for effort estimation used in software development projects with agile methods that seek to identify metrics or estimation processes that can be used to meet current Brazilian normative restrictions.

Brazilian legislation for contracting software development by the government

- In Brazilian Federal Public Administration (FPA), software development is submitted to a very restrictive normative scope when it comes to setting delivery dates at the moment of hiring specialized services for these specific ends.
- With the advent of Normative Instruction IN 04/2008 and its constant alterations culminating in the current version, the IN 01/2019 from the Digital Government Department in the Ministry of Economy (DGD/ME) has equivalent legislations related to the other powers (Legislative and Judiciary).

Function Points in Brazil

- The IN 01/2019 regulates the requirements for hiring Information Technology services in the sphere of the Federal Executive Power. This period of time (2008-2019) and the adoption of metrics like the Function Point (FP) technique for compensating the hired effort have brought a number of discrepancies that, in many cases, do not comprehend the real cost attributed to a commission.
- Brazilian law requires payment for results but there is a discrepancy between the effort undertaken and the pricing process carried out by the contracting public institution

Software Metrics

Software metrics aims to control and efficiently identify essential parameters that affect software development, as well as characteristics that cannot always be objectively measured.

COCOMO II

Is a technique and tool for algorithmic modelling of costs. This empirical model was derived from the collection of data from various software projects of different sizes.

This technique is usually linked to metrics and has four (4) basic models (application composition model; early design model; reuse model; and, post-architecture model), depending on the metrics used, as seen in the FP and LOC (Lines of Code) studies

Function Point Metric

Were created from a principle stating that projects must be completed at a pre-established deadline, respecting the budget, and satisfying the client.

In Brazil, this technique has had accentuated growth, especially in the federal government sphere, with actions from Brazil's Federal Court of Accounts (TCU) and the publication of IN 02/2008 and IN 04/2008, both from actual Ministry of Economy.

Systematic Review Planning

1. Planning

- Formulate the Research Question
- Define Research Protocol

2. Execution

- Conduct search in research bases
- Identify studies through title and abstract
- Retrieve articles from databases
- Select studies according to the criteria

3. Result

- Extract Data
- Evaluate quality

Literature Review Methodology



Research Questions

+ RQ1

What metrics adequately reward the effort applied in the construction of a software functionality?

+ RQ2

What metrics, according to the normative Brazilian framework, can be used to reward a supplier in cases where software development is outsourced by an FPA entity?

+ RQ3

What metrics techniques are used in prompt methods and measure effort, deadline, cost and size involved in software development?

+ RQ4

Is FP Metrics used for calculating the payment of services in contracts outside of Brazil?



Selected Bases

BASE	ADDRESS	SEARCH
ACM Digital Library	https://dl.acm.org/	Automatic
IEEE Xplore	https://ieeexplore.ieee.org/	Automatic
ScienceDirect – Elsevier	https://link.springer.com/	Automatic
Annals SBES	The address is changed every year according to the organization of the event.	Manual
Annals SBQS	The address is changed every year according to the organization of the event.	Manual

Search Strings

ID	BASE	ADDRESS
1	ACM Digital Library	[[All: "smart contract"] OR [All: metric]] AND [[All: "agile development"] OR [All: "agile"]] AND [[Abstract: "effort"] OR [Abstract: "cost"]] AND [[All: "smart contract"] OR [All: "metric"]] AND [Publication Date: (01/01/2010 TO 12/31/2019)]
2	IEEE Xplore	((("All Metadata":smart contract OR Metric) AND "All Metadata":"agile development" OR agile) AND "All Metadata":effort) AND "All Metadata":cost)
3	ScienceDirect – Elsevier	("smart contract" OR metric) AND ("agile development" OR agile) AND (effort OR cost) Abstract Effort OR cost
4	Springer	'("smart contract" OR metric) AND ("agile development" OR agile) AND (effort OR cost) AND "effort estimation"

Criteria for Inclusion

CI	CRITERIA FOR INCLUSION
1	Studies that show empirical or theoretical data or reports of experiences about metrics applied to payment based on the effort involved in the development of a software system;
2	Studies of quantitative and qualitative Research;
3	Primary and secondary studies;
4	Studies written in English and Portuguese;
5	Studies written in English and Portuguese;

Criteria for Exclusion

CI	CRITERIA FOR EXCLUSION
1	Repeated articles;
2	Similar articles;
3	Inaccessibility;
4	Article is not written in Portuguese or in English;
5	Published as short paper or only as a poster;
6	Article without an abstract;
7	Studies did not focus on metrics for the payment of services;
8	Studies based solely on the opinion of specialists, not pointing to a specific experience;
9	Editorials, prefaces, forewords, article abstracts, interviews, news articles, analysis, tutorials, correspondence, discussions, commentaries, letters to readers, tutorial summaries, workshops, and panels.

Result Studies

Technique for Estimation	Quantity
Primary Study	85
Systematic Mapping	2
Literature Review	6
Systematic Review	13
Total	106

Table VII - Type of study

Result Studies

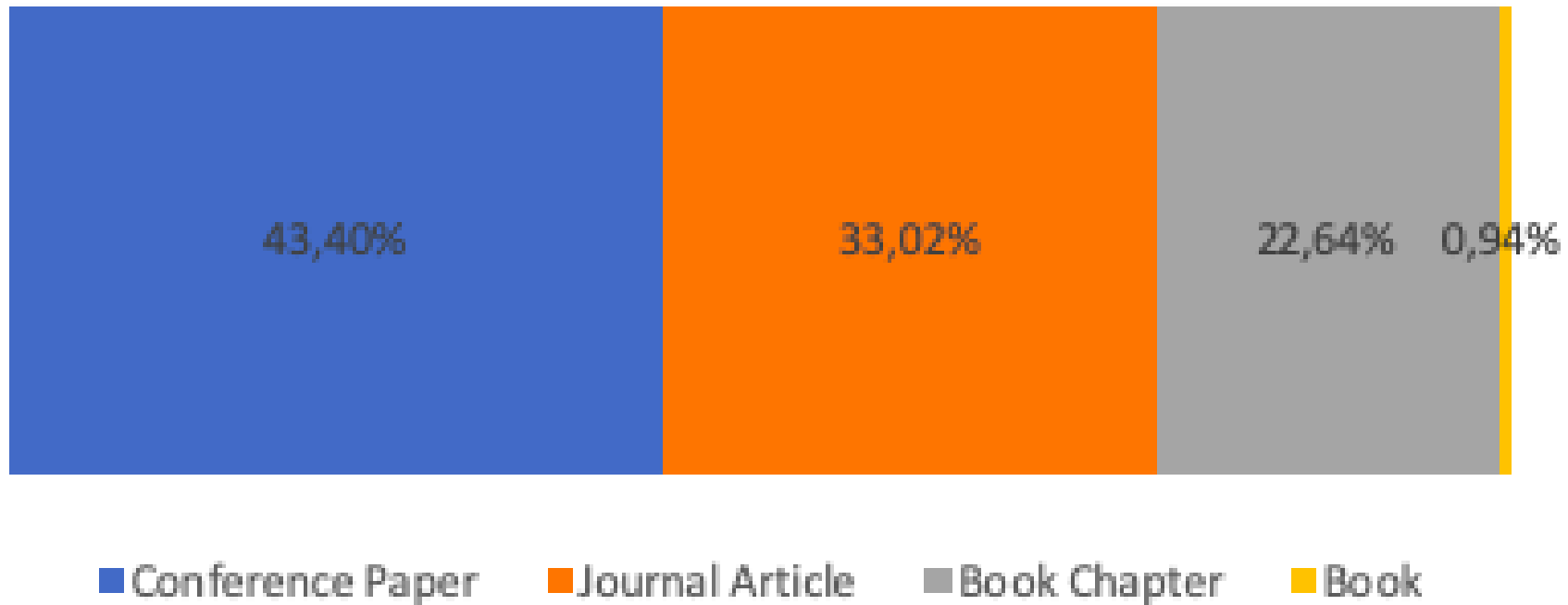


Figure 2 - How the papers were published

Result Studies

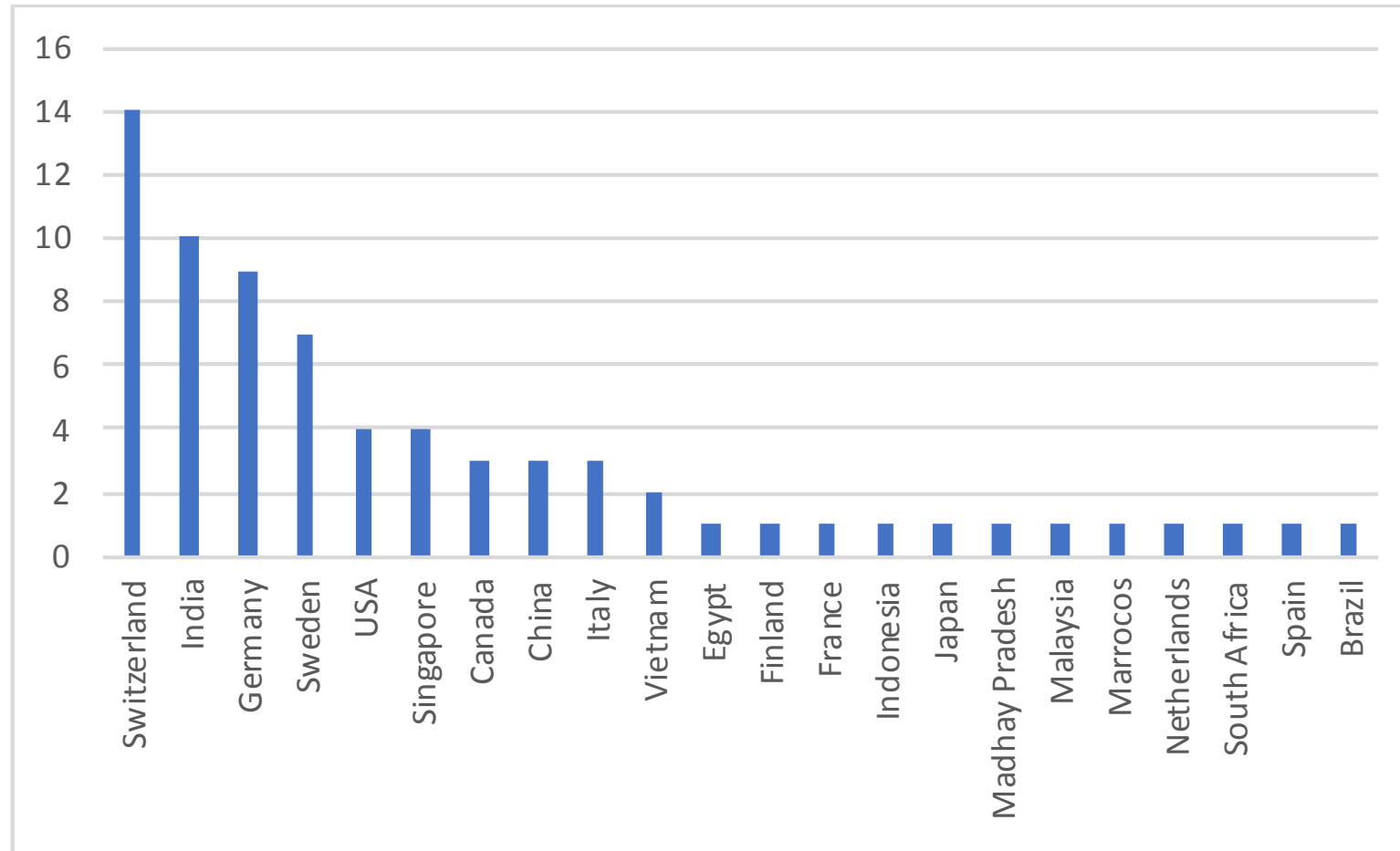


Figure 3: Countries where the conferences were held

Result Studies

Journal	Publisher	Quantity
Journal of Systems and Software	Elsevier	7
Empirical Software Engineering	Springer	6
Information and Software Technology	Elsevier	5
Innovations in Systems and Software Engineering	Springer	3
Procedia Computer Science	Elsevier	3
Journal of King Saud University - Computer and Information Sciences	Elsevier	2
Others (with 1 study)	ACM, Springer and Elsevier	9
Total		35

Table VIII: Articles selected according to base

Result Studies

Estimation Technique	Quantity
Regression-Based	2
Model-Based	7
Learn-Based	20
Expert-Based	38
Dynamic-Based	2
Total	69

Table IX: Classification of articles and the estimation technique they adopted.

Result Studies

Metrics	Kind of Measurement	Quantity
FP	Functional	10
COSMIC	Functional	4
UCP (Use Case Point)	Functional	5
SP (Stories Points)	Complexity	21
Velocity	Complexity	4
LOC or kLOC	Size	4

Table X: Techniques and metrics found

Discussions

Q1: Does the metrics adequately reward the effort applied to the construction of a software functionality?

Yes, we found several metrics techniques that can assess the effort applied in the construction of a software functionality, from parametric models like COCOMO [16]–[19] to its evolution COCOMO II [20][21] and this model requires a wide historical basis that is often based on functional measurement metrics like FP [22] and COSMIC [23]–[25] in addition to some studies that used LOC [26].

Discussions

Q2: Can the metrics be used in accordance with the Brazilian normative framework for rewarding the supplier of software development is outsourced by an entity of the federal public administration?

Yes, for functional measurement metrics, FP and COSMIC, but several metrics in more extensive studies using metrics applied to agile methods as Velocity [27], Sprint Points [28], Story Points [29] and Delivery Stories [30]. In some cases, it was combined with multiple factors techniques [31] to improve the precision and algorithms with verification list, even so machine learning use [32].

Discussions

Q3: Is the metric used in agile methods and measure effort, deadline, cost and size involved in software development?

Yes, the same works presented in Q2 are about agile methods and measure these 3 aspects focused on software maintenance activities [33] and bugs fix [34].

Twenty studies focus in the use of machine learning techniques with the most diverse techniques since genetic algorithms [35], Bayesian statistics [36], fuzzy logic [37], [38], neural networks [38][39] and machine learning with multiple approaches [35][37][40][41].

Therefore, the most used are techniques based on expertise with an analogy (Expert-Based). It is presented in the studies several uses of the metrics in agile methods, mixing functional measure as FP already cited, or COSMIC [22]–[24][42] and classic agile metrics combined with multiple factors to precision calibration [26][27][43]–[45].

Discussions

Q4: Is FP Metric used for calculating the payment of services in contracts outside of Brazil?

FP metric was found in 10 studies. The study of Russo et al. [47] is about FP used by the Italian public sector to critical service outsourcing. However, the metric is used to evaluate the functional size, deriving from this, productivity with effort and cost. Besides, the work explains Scrum Points that would be a fixed value of Hours inside a Sprint, for example, 40 hours, and the deliveries are made within open scope system.

Another one [48], is about FP within a Dynamic-Model technique, a combination of Dynamic-Bases activity and Model-Based applied on agile development. But an old study from 2010 and another one use COCOMO as technique with Unadjusted Function Points (UFP) that would not be the FP use based on IFPUG manual. The other studies [10][17][21][48]–[51] use analogy estimation mixing teams experience estimation with analogy and some agile metrics besides FP.

Limitations

- Research looked for metrics used to pay for effort and that can be adopted in Brazil following the Brazilian normative framework.
- The research found specific studies that dealt with the adoption of metrics in public organizations outside of Brazil.

Conclusion

The most found metric in the studies was Story Points (which is based on a combination of the amount of effort involved in the development of a feature).

Functional metrics, with a large advantage of Function Points (in the Brazilian case, in response to the regulations and guidelines of the control agencies), are second in the ranking. LOC, code size metric, performs last in studies, as it is a measure that we can consider linked to paradigms and technologies that are no longer in use.