Protocol Employed:

Research question:

What methods have been used to construct software engineering productivity measures when there is no single dominant size measure?

We have also considered an additional research question:

What explicit assumptions have software engineers made in productivity studies?

Population: commercial software projects
Intervention: methods to construct productivity measures when there is no single dominant size measure

Outcomes: productivity measurement methods
Experimental design: any

The strategy that will be used to search for primary studies:

This will be based solely on a search of electronic databases including the following journals and conferences. We will not attempt to access grey literature or undertake any additional hand-searches.

Terms to use:
Resources: IEEE journals, IEE journals, IEE, IEEE conferences
A list of the journals and the volumes of each journal and conferences included in the databases is provided at the end of this document.

Study selection criteria and procedures:

Criteria for including study: software productivity measurement study where there is no single dominant size measure.
Secondary question: inclusion of a discussion of assumption underlying productivity measurement/analysis
Criteria for excluding study: software productivity measurement study where there is only single dominant size measure.
Secondary question: studies that use productivity measures without commenting on underlying assumptions.

Preliminary selection process:

One researcher will apply the search strategy to identify potential primary studies.

Both researchers will check titles and abstracts of all potential primary studies against inclusion criteria.
Results will be checked and any disagreements discussed and resolved. If resolution is impossible the study will be included.

Final selection process:

Copies of all papers included as a result of the initial study will be reviewed by at least one of the researchers. A random selection of papers (up to 20%) will be reviewed by both researchers. Note if fewer than 10 papers are identified each reviewer will review every paper. This review will finalise the selection of papers to be included in the data extraction process. Any disagreements in papers jointly reviewed will be discussed and resolved. If resolution of the dispute is not possible, the paper will be included.

Study quality assessment checklists and procedures:

We do not assume we have any explicit quality assessment checklists. We are looking for studies that include a rationale for handling multiple size measures and/or a discussion of assumptions underlying productivity measurement.

Therefore the only issue is that a description of the productivity measurement method is included in the paper – and this is part of data extraction

Data extraction strategy:

For each paper remaining after the selection process has been completed. The researches will extract the following data:

Standard Reference information
For main question:
Type of paper: Theoretical, Empirical, Both
Specification of size measures
Description of construction of productivity measure or measurement process
Application type or industry sector of projects for which measure is appropriate (for theoretical discussion) or used (for empirical paper)

For secondary question
Type of paper: Theoretical, Empirical, Both
Definition of productivity
List of all assumptions mentioned.

If less than 10 papers remain both researchers will extract the data from all papers and compare their results. Otherwise papers will be distributed equally to each reviewer such that all paper are assigned to at least one researcher and at least 20% of papers are read by both researchers.

Synthesis of the extracted data:

Results will be tabulated and presented in the next Section

No meta-analysis is required.

Searches IEEExplore (last 10 years)

Search criteria: (commercial <or> business <or> industrial <or> business-related) <and> software project <or> software development <and> (method <or> process <or> system <or> technique <or> methodology) <and> (productivity <or> production <or> efficiency) <and> (measure <or> metric <or> attribute <or> indicator <or> variable <or> measurement) <and> size

Retrieved 104 papers

Tabulated results:

Related to Main question:

Table 1 – tabulated results for primary question

Reference	Type of Paper	Specification of Size measures	Description of construction of productivity measure or measurement process	Application type of projects for which measure is appropriate or used	Industry sector of projects for which measure is appropriate or used
Moser and Nierstrasz 96	Empirical	Two aggregate size measures: Function Points (Albrecht, Mark II) and System Meter. The System Meter is defined as the sum of two parts: an object's external size/complexity, and an object's inner size/complexity. Both measures	Productivity measured as size divided by effort (person-days). Two measures are used: Function points/effort, and System Meter/effort. Effort is measured as person-days.	Workflow administration, land registry, statistics, taxation, registration of chemical formulas, decision support, MIS.	Information Services, Tertiary education, Chemical industry

		provide models to support the aggregation, however none has been validated.			
Morasca and Russo 01	Empirical	An aggregate size measure: IFPUG Function points; two single size measures: Lines of Code, Number of Modules. The aggregate measure provides a model to support the aggregation; however it has not been validated.	Three productivity measures: Function points/effort; Lines of Code/effort; Number of modules/effort. Effort is measured as person-hours.	Project Monitoring, Project Accounting, Decision Support Systems	Public Administration Sector
Hastings and Sajeev 01	Theoretical and Empirical	An aggregate size measure: vector size measure (VSM). This size measure is calculated as the magnitude of a two-dimensional vector that represents two orthogonal dimensions - software functionality and problem complexity, which themselves have been calculated using ADTs	Productivity is not measured in this study.	Control system, Operating system, System management, Management Information.	Communications, System, Banking, Accounting

		specified using an algebraic specification language. A valid model to support the aggregation is provided, however the model does not extend to more than two "orthogonal dimensions". .			
Maxwell and Forselius 00	Empirical	An aggregate size measure: Experience 2.0 Function points	Productivity measured as function points/effort. Effort is measured in hours.	None presented	Banking, Insurance, Manufacturing, Wholesale-and-retail, Public administration
Arnold and Pedross 98	Empirical	An aggregate size measure: use case points (adaptation of function points). Do not provide a model to support the aggregation.	Productivity is measured as use case points divided by effort. No effort unit is given.	No details are provided.	Banking
Chidamber et al. 98	Empirical	A single size measure: Lines of code in a class.	Productivity is measured as Lines of code in a class/effort. Effort is measured in hours.	Object-oriented financial application systems	Banking
Stensrud and Myrtveit 03	Empirical	Three size measures: Users, EDI, Conversions.	Productivity is measured using Data Envelopment Analysis with a Variable Returns to	COTS software, ERP projects	IT Consulting

			Scale (VRS) model. Effort is measured in workdays.		
MacCormack et al. 03	Empirical	LOC	Productivity is measured as the number of new lines of code developed per person-day.	Application software, systems software, embedded software projects	High-technology firm

Related to Secondary question:

Table 2 – tabulated results for secondary question

Reference	Type of Paper	Definition of Productivity	Revealed Assumptions
Moser and Nierstrasz 96	Empirical	Productivity is defined as "the total functionality delivered per person-days of effort spent". Productivity is taken as the incremental functionality developed divided by effort (person-days).	Only the incremental functionality is used in the productivity measure in order to factor out reusable components. Assumes that the unchanged functionality provided by reusable components should not be considered for productivity assessment. The productivity measure proposed should only be applied to object-oriented projects. Assumes that an appropriate measure of size is strongly associated with effort.
Morasca and Russo 01	Empirical	Productivity is defined as "the ratio of the amount of product to the amount of resources used to generate it". Productivity is classified as having two views: external and internal; the external view is represented as an	For both external and internal views of software size, the entire software size is considered without taking reuse into consideration. Assumes that an appropriate measure of size is strongly associated with effort.

		aggregate size measure (external view, e.g. function points) divided by effort, and the internal view is represented as single size measures (internal view, e.g. LOC or number of modules) divided by effort. Effort is measured as person-days.	
Hastings and Sajeev 01	Theoretical and Empirical	Productivity is defined as "the measured size of the software system divided by the measured total actual effort used to produce a solution."	No assumptions are presented.
Maxwell and Forselius 00	Empirical	Productivity is defined as "output divided by the effort required to produce that output."	No assumptions are presented.
Arnold and Pedross 98	Empirical	Productivity is defined as "productivity is computed by dividing the size by the effort".	No assumptions are presented.
Chidamber et al. 98	Empirical	No definition of productivity is provided explicitly.	No assumptions are presented.
Stensrud and Myrtveit 03	Empirical	Productivity is defined as "the output over input ratio. … The usual input is effort, and the output is the amount of product delivered. The amount of product must be represented by some size measure."	COTS software projects have multi-dimensional outputs and thus require using multi-dimensional size measures. Also assumes that returns to scale should be variable rather than constant. Size must be related to effort.
MacCormack et al. 03	Empirical	"the number of lines of new code developed by person-day".	No assumptions are presented.

Journals and Magazines:

IEE - Electronics Systems and Software (2003 - 2004)
IEEE Transactions on Software Engineering (1988 – 2004)
IEE Proceedings IEE - Software (1998-2004)
IEE Proceedings Software Engineering (1997 - 1997)
Software Engineering Journal (1988 - 1996)
Software Engineering Journal (1988 - 1996)
IEEE Software (1988 – 2004)

Conference Proceedings: (software)

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Advances in Software Engineering for PLC
Application of Computer Aided Software Engineering Tools, IEE Colloquium on
Application-Specific Software Engineering Technology, 1998. ASSET-98. Proceedings. 1998 IEEE Workshop on
Application-Specific Systems and Software Engineering and Technology, 1999. ASSET '99. Proceedings. 1999 IEEE Symposium on
Application-Specific Systems and Software Engineering Technology, 2000. Proceedings. 3rd IEEE Symposium on
Are Software Development Technologies Delivering Their Promise?, IEE Colloquium on
Artificial Intelligence in Educational Software (Digest No. 1998/313), IEE Colloquium on
Assessment and Certification of Software, IEE Colloquium on
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Assessment of Software Tools and Technologies, 1997., Proceedings Fifth International Symposium on
Assessment of Software Tools, 1996., Proceedings of the Fourth International Symposium on
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Automated Software Engineering, 2003. Proceedings. 18th IEEE International Conference on
Automated Testing and Software Solutions, IEE Colloquium on
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Computer Software and Applications Conference, 1992. COMPSAC '92. Proceedings., Sixteenth Annual International
Computer Software and Applications Conference, 1993. COMPSAC 93. Proceedings., Seventeenth Annual International
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Computer Software and Applications Conference, 1996. COMPSAC '96., Proceedings of 20th International
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