ISESS`99
4th IEEE International Software Engineering Standards Symposium
Curitiba, Brazil, 17-22 May 1999

II China-Brazil Workshop on Quality & Software
Curitiba, Brazil, 19 May 1999

SOFTWARE QUALITY AND PRODUCTIVITY IN BRAZIL

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ABSTRACT

Brazil is looking for the achievement of international standards on quality and productivity in the software sector. This paper focuses on the status of software process quality improvements and software product quality evaluations in Brazil. It shows that software quality has been continuously improved in Brazil since the beginning of the 1990s. However, the paper asserts that Brazil lacks a nationwide effort, similar to the quality one, to increase the Brazilian software productivity. It also introduces a new technique named SP (Systemic Productivity) which is beginning to be used in the Brazilian software industry.

1. INTRODUCTION

Brazilian software is a critical leverage tool for Brazil´s drive to compete in the global marketplace, from agribusiness to the telecom and aerospace industries, and to improve education and health care for solving acute social problems.

The software industry itself is also becoming an important player to the Brazilian economy. It is made up of developers of packaged and custom software, companies which embed software in their products, and companies which develop Internet-related software.

According to the SEPIN/MCT, the Brazilian informatics activities have grown and generated important revenues in the domestic front in the 1990s (see Table I).

	REVENUES (US$ billion)		Growth Rate
	1991	1997	
Software (1)	**1.1**	**3.2**	**190%**
Related Services (2)	1.9	4.3	126%
Hardware (3)	4.1	7.5	83%
TOTAL	7.1	15.0	111%

Source: MCT/SEPIN (http://www.mct.gov.br/sepin)
(1) Only packaged and custom software, 60% of them developed in Brazil
(2) It includes software-related services
(3) It includes embedded software

Table I - Software Revenues in Brazil

As shown in Table I, the growth rate in software revenues had the best performance in the domestic market from 1991 to 1997, when compared to hardware and related services. Another important SEPIN/MCT figure concerns to the investments in research and development (R&D) divided by the revenues: in 1991, the hardware industry accounted for 3.5% and the software for 4.6%; while, in 1997, the hardware sector invested 5.0% and the software 8.0%. Therefore, also in R&D, the Brazilian software industry achieved a better performance in the same period.

In the export front, the work of the Brazilian Society for Promoting Software Export - SOFTEX is beginning to show positive results. Brazilian software's revenues from export were US$ 27 million in 1997, an evolution compared to less than US$ 1 million exported in 1991. The main goal is to export US$ 250 million in 2002 or, in other words, to shift Brazilian software exports to hundreds of millions each year.

Quality and productivity improvements are crucial for Brazilian industries, including the software one. In 1990, the Brazilian government created the PBQP (Brazilian Quality and Productivity Program) and installed the PBQP/SSQP-SW (PBQP Software Subcommittee) in 1993.

The PBQP Software Subcommittee is the coordinator of a nationwide program, which embodies industry, government, and academy voluntary representatives, aiming:
a) to improve the quality of software processes;
b) to evaluate the quality of software products; and
c) to increase software productivity.

As reported by Weber and Pinheiro (1995), the PBQP Software Subcommittee is looking for "the achievement of international standards on quality and productivity in the software sector."

In this sense, the objectives of this paper are:
a) in **quality management**, to present the main results of software process quality improvements and software product quality evaluations achieved in Brazil in the 1990's; and
b) in **productivity management**, to show that Brazil lacks a nationwide effort similar to the quality one in order to increase productivity in the software industry, and to present a new technique named SP (Systemic Productivity).

2. SOFTWARE QUALITY IN BRAZIL

As Capers Jones (1995) noticed: "For many years, software quality assurance lagged behind hardware quality assurance in terms of methods, metrics, and successful results. New approaches such as Quality Function Deployment (QFD), the ISO 9000-9004 standards, the SEI maturity levels, and Total Quality Management (TQM) are starting to bring software quality levels up to a parity with manufacturing quality levels."

But, how mature is the quality of the Brazilian software nowadays? This industry is improving continuously both the quality of software processes and its products, based on the systematic use of the Deming cycle (PDCA) adopted by the PBQP Software Subcommittee since 1993.

2.1 SOFTWARE PROCESS QUALITY IMPROVEMENTS

Software process quality improvements in Brazil are mainly based on the ISO 9000 Quality Management System. It applies the 17 software processes defined by the International Standard ISO/IEC 12207 – Information Technology: Software Life-cycle Process.

According to Weber and Rocha (1999), in 1995, in a survey of 445 Brazilian software companies, only 2% were ISO 9000 certified; in 1997, in a survey of 589 software companies, this number grew to 8 %; and, in 1999, it is expected to achieve 20%.

Weber et al (1997), for instance, reported a creative and innovative experience which joined 10 Brazilian software companies to achieve ISO 9000 certification, in a cooperative scheme, coordinated by CITS (International Center for Software Technology), in Curitiba, PR, Brazil.

During the 1990s, Brazil has gone through a learning process that will spread throughout the Brazilian software industry the use of software process improvement techniques such as the CMM (Capability Maturity Model), PSP (Personal Software Process), and TSP (Team Software Process). All these techniques were developed by Watts S. Humphrey, from CMU/SEI (Carnegie Mellon University/Software Engineering Institute), in Pittsburgh, PA, USA.

There are several institutions in Brazil able to render services based on these software quality improvement techniques. The main ones are CITS/CNTS, in Curitiba, PR; USP/FCAV, in São Paulo, SP; CTI, in Campinas, SP; and UFRJ/COPPE, in Rio de Janeiro, RJ.

In Brazil, there is also an active branch of the SPICE (Software Process Improvement and Capability dEtermination) international project. On the standardization front, there is a Working Group (WG) in the ABNT/SC21: 10 (Brazilian Software Standardization Subcommittee) dealing with the technical report ISO/IEC TR 15504-1: Software Process Assessment, Part 1: Concepts and Introductory Guide. On the experimental application front, CTI leads this process, in Campinas, SP, Brazil.

The main metrics used in Brazil for software process quality analysis are the following:
a) the lines of code (LOC) metric, as the older one; and
b) the function point (FP) metric, as a new one.

2.2 SOFTWARE PRODUCT QUALITY EVALUATIONS

In Brazil, the quality evaluation of the software products is based on ISO/IEC 9126 - Software Product Evaluation: Quality Characteristics and Guidelines for their Use. Their international standards derivatives are also used: ISO/IEC 14598 - Software Product Evaluation and ISO/IEC 12119 – Information Technology: Software Packages Quality Requirements and Testing.

The ABNT/SC21: 10 Working Group which deals with software product evaluation standards is well known in the main international standardization forums, as mentioned by Weber et al (1999).

It is very familiar in Brazil the software product evaluation scheme used by CTI, in Campinas, SP, reported by Tsukumo et al (1995) in the 2nd IEEE International Software Engineering Standards Symposium (ISESS'95), in Montreal, PC, Canada.

As shown by Weber and Rocha (1999), it is growing the number of software product quality testing laboratories in Brazil, based on the ISO/IEC 9126. There was only one in 1995 (CTI, in Campinas,SP); five in 1997 (CTI and SOFTEX Campinas, in Campinas, SP; USP/ICMC, in São Carlos, SP; UFRGS/CEI/II, in Porto Alegre, RS; and SOFTEX Insoft, in Fortaleza, CE); and, it is expected to achieve seven in 1999.

The figures on Brazilian commercial software products evaluated by a third party, based on ISO/IEC 9126 are the following: 25 in 1995; 148 in 1997; and it is expected to achieve 210 in 1999, as reported by Weber and Rocha (1999).

In the Brazilian academy, there is an important R&D activity on software product evaluation at the UFRJ/COPPE, in Rio de Janeiro, RJ. There is a strong interaction among the main academic R&D teams, industry, and government to improve software quality in Brazil.

Last but not least, according to SOFTEX's surveys (http://www.softex.br), made by the Internet in the US, Europe, and Brazil, in 1997 and 1998, quality ranked among the best attributes of the Brazilian software products.

3. SOFTWARE PRODUCTIVITY IN BRAZIL

3.1 SOFTWARE PRODUCTIVITY

According to Capers Jones (1997), "no single approach by itself is adequate to make large gains in software productivity. But multiple, concurrent improvements (such as experienced staff, good software practices, better tools, and more powerful programming languages) can create impressive results."

The main metrics used in Brazil for software project productivity are the following:

a) the lines of code (LOC) metric, which was more effective in the past when the code was the dominant cost driver; and
b) the function point metric (FP), which use is growing worldwide its use in the 1990s.

Brazil has national databases of software quality information at the SEPIN/MCT (http://www.gov.br/sepin), but still lacks software productivity information.

3.2 SYSTEMIC PRODUCTIVITY

The productivity concept is used in the macroeconomic area as a country performance indicator. One of the most used worldwide is the GDP (Gross Domestic Product) per capita, employed without perceiving that we are talking about productivity.

Productivity, however, has been used in companies and institutions to evaluate and improve their performance, usually as a synonymous of efficiency in the resources application. Several indicators as income per employee, production per machine or equipment, and return on investment are productivity indicators well used by managers from different companies and institutions.

Productivity can be defined as the ratio between the obtained results and the used means (resources), that is

Productivity = Output/Input

In all the above-mentioned indicators, only one process input should be considered as the representative of the whole.

Specifically for the Brazilian software industry, the average productivity among the companies in terms of income per employee/year can be estimated around U$ 50.000. This number is still low when compared to the US software industry with a productivity of U$ 143.770 per employee/ year, as published by the Business Week (1999).

In order to meet the new economic reality, new productivity models started to be developed. One of these models to supply the new demand is the Total Factor Productivity (TFP). Used during many years as a measure of competitiveness among countries, and more recently among enterprises, this model relates productivity to two combined production factors, capital and labor, having variation rates in the management improvement and technological innovation as sub-product of the analysis.

Other factors such as natural resources can be included in the calculation of the multifactor productivity. Although the percentage of GDP resulted from the natural resources is even smaller in the Knowledge Society for the next millenium, this is a resource that cannot be discarded. As Peter Drucker (1993) argues, it still has not arisen one Adam Smith or one David Ricardo from the Knowledge Society to explain the next century economy.

Based on this premise and adding the General Theory of Systems from Bertalanffy, in which a system cannot be significantly described in terms of its isolated elements but globally, considering all the inter-dependence of its subsystems, a new model considered adequate to the reality of public and private organizations was created. This new model is called **Systemic Productivity (SP).**

The production factors (inputs) can be defined as people, natural resources, inventory, facilities, and management, besides two references: comparison of results (benchmarking) and distribution of value added.

The mathematical formulation of the Systemic Productivity is similar to the one that Paul Krugman, from MIT, uses to explain the Asian crisis (web.mit.edu/krugman/www).

Since Productivity = Output/Input in macroeconomic terms, it is possible to argue that

$$\textbf{Systemic Productivity (SP)} = \frac{\textbf{Total of Value Added in the country (VA)}}{\textbf{Total Quantity of all the consumed resources (Q)}}$$

Applying the Napierian logarithm to both sides of the equation

$$\ln SP = \ln VA/Q$$

as the logarithm of a division is equal to the subtraction of logarithms of the numerator and the denominator

$$\ln SP = \ln VA - \ln Q$$

or transferring the negative component to the other side of the equation

$$\ln VA = \ln SP + \ln Q.$$

Deriving in the time both sides of the equation and calling the derivative in the time of a logarithm of T

$$\mathbf{T\ (VA) = T\ (SP) + T\ (Q)}$$

This formula shows that the variation rate in VA (value added or richness) is equal to variation rate in Q (resources) plus the variation rate in SP (Systemic Productivity). In this sense, it is possible to grow up faster adding continuously more capital and people to the processes or increasing the systemic productivity with new technologies and management creativity. This formula is valid either for companies or countries.

Any country that wants to provide a sustainable economic growth to its population, generating social welfare and quality of life in a growing and continuous way, needs to pay attention not just to people, investments, natural resources, and available technologies, but mainly to the achievement of growth rates in SP (Systemic Productivity) which support long-term development. The same type of reasoning can be done for a public institution or for a private company.

In 1999, the Brazilian software industry was chosen by IBQP-PR to develop a group of productivity indicators that could be used not only as benchmarking, but also as a source of studies to make a more accelerated productivity gain feasible to the Brazilian software companies. Such indicators will include a value-added analysis, which will make possible a better mapping out of typical characteristics of the Brazilian software industry.

In a preliminary analysis made by IBQP-PR, data such as the high percentage of value added applied to human resources and the difficulty in measuring the value of software products, trademarks, business potential, and intellectual potential, show the need for a differentiated treatment of the Brazilian software companies in order to have a coherent analysis of their productivity.

IBQP-PR uses modern techniques in the productivity field, most of them obtained through an agreement with JICA (Japan International Cooperation Agency) that has technical support from JPC-SED (Japan Productivity Center for Socioeconomic Development).

4. CONCLUSIONS

Since 1993, the quality of the Brazilian software has been continuously improved, both in processes and products. In Brazil, software process quality improvements are mainly based on ISO 9000 and the number of Brazilian software companies which have achieved ISO 9000 certification has grown fast. Software product quality evaluations are mainly based on ISO/IEC 9126 and there is a growing number of Brazilian commercial software products evaluated based on this testing scheme. As a consequence, quality is currently ranking among the best attributes of the Brazilian software products.

Brazil has national databases of software quality information, but lacks software productivity information since the focus from 1993 to 1998 was mainly on software quality improvements. As of 1999, the Brazilian software quality and productivity will both be equally focused. In the 1999 survey of the Brazilian Software Quality and Productivity, the measurements of software project productivity and Systemic Productivity (SP) will start to be done within the Brazilian software industry. Brazil is looking for the achievement of international standards in the software sector, both on quality and productivity.

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